AD NO. ______________________
DTC PROJECT NO. 8-CO-160-UXO-021
REPORT NO. ATC-8827

STANDARDIZED

UXO TECHNOLOGY DEMONSTRATION SITE

BLIND GRID SCORING RECORD NO. 362

SITE LOCATION:
U.S. ARMY YUMA PROVING GROUND

DEMONSTRATOR:
U.S ARMY CORPS OF ENGINEERS
ENGINEERING RESEARCH AND
DEVELOPMENT CENTER
3909 HALLS FERRY ROAD
VICKSBURG, MS 39180-6199

TECHNOLOGY TYPE/PLATFORM:
TM-4 MAG/MAN PORTABLE

PREPARED BY:
U.S. ARMY ABERDEEN TEST CENTER
ABERDEEN PROVING GROUND, MD 21005-5059

MARCH 2005

Prepared for:
U.S. ARMY ENVIRONMENTAL CENTER
ABERDEEN PROVING GROUND, MD 21010-5401

U.S. ARMY DEVELOPMENTAL TEST COMMAND
ABERDEEN PROVING GROUND, MD 21005-5055

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14. ABSTRACT
This scoring record documents the efforts of U.S. Army Corps of Engineers Engineering Research and Development Center (ERDC) to detect and discriminate inert unexploded ordnance (UXO) utilizing the YPG Standardized UXO Technology Demonstration Site Blind Grid. The scoring record was coordinated by Larry Overbay and by the Standardized UXO Technology Demonstration Site Scoring Committee. Organizations on the committee include the U.S. Army Corps of Engineers, the Environmental, Security Technology Certification Program, the Strategic Environmental Research and Development Program, the Institute for Defense Analysis, the U.S. Army Environmental Center, and the U.S. Army Aberdeen Test Center.

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SECTION 1. GENERAL INFORMATION

1.1 BACKGROUND

Technologies under development for the detection and discrimination of unexploded ordnance (UXO) require testing so that their performance can be characterized. To that end, Standardized Test Sites have been developed at Aberdeen Proving Ground (APG), Maryland and U.S. Army Yuma Proving Ground (YPG), Arizona. These test sites provide a diversity of geology, climate, terrain, and weather as well as diversity in ordnance and clutter. Testing at these sites is independently administered and analyzed by the government for the purposes of characterizing technologies, tracking performance with system development, comparing performance of different systems, and comparing performance in different environments.

The Standardized UXO Technology Demonstration Site Program is a multi-agency program spearheaded by the U.S. Army Environmental Center (AEC). The U.S. Army Aberdeen Test Center (ATC) and the U.S. Army Corps of Engineers Engineering Research and Development Center (ERDC) provide programmatic support. The program is being funded and supported by the Environmental Security Technology Certification Program (ESTCP), the Strategic Environmental Research and Development Program (SERDP) and the Army Environmental Quality Technology Program (EQT).

1.2 SCORING OBJECTIVES

The objective in the Standardized UXO Technology Demonstration Site Program is to evaluate the detection and discrimination capabilities of a given technology under various field and soil conditions. Inert munitions and clutter items are positioned in various orientations and depths in the ground.

The evaluation objectives are as follows:

a. To determine detection and discrimination effectiveness under realistic scenarios that vary targets, geology, clutter, topography, and vegetation.

b. To determine cost, time, and manpower requirements to operate the technology.

c. To determine demonstrator's ability to analyze survey data in a timely manner and provide prioritized "Target Lists" with associated confidence levels.

d. To provide independent site management to enable the collection of high quality, ground-truth, geo-referenced data for post-demonstration analysis.

1.2.1 Scoring Methodology

a. The scoring of the demonstrator's performance is conducted in two stages. These two stages are termed the RESPONSE STAGE and DISCRIMINATION STAGE. For both stages, the probability of detection (P_d) and the false alarms are reported as receiver-operating

characteristic (ROC) curves. False alarms are divided into those anomalies that correspond to emplaced clutter items, measuring the probability of false positive (P_{fp}), and those that do not correspond to any known item, termed background alarms.

b. The RESPONSE STAGE scoring evaluates the ability of the system to detect emplaced targets without regard to ability to discriminate ordnance from other anomalies. For the blind grid RESPONSE STAGE, the demonstrator provides the scoring committee with a target response from each and every grid square along with a noise level below which target responses are deemed insufficient to warrant further investigation. This list is generated with minimal processing and, since a value is provided for every grid square, will include signals both above and below the system noise level.

c. The DISCRIMINATION STAGE evaluates the demonstrator's ability to correctly identify ordnance as such and to reject clutter. For the blind grid DISCRIMINATION STAGE, the demonstrator provides the scoring committee with the output of the algorithms applied in the discrimination-stage processing for each grid square. The values in this list are prioritized based on the demonstrator's determination that a grid square is likely to contain ordnance. Thus, higher output values are indicative of higher confidence that an ordnance item is present at the specified location. For digital signal processing, priority ranking is based on algorithm output. For other discrimination approaches, priority ranking is based on human (subjective) judgment. The demonstrator also specifies the threshold in the prioritized ranking that provides optimum performance, (i.e. that is expected to retain all detected ordnance and rejects the maximum amount of clutter).

d. The demonstrator is also scored on EFFICIENCY and REJECTION RATIO, which measures the effectiveness of the discrimination stage processing. The goal of discrimination is to retain the greatest number of ordnance detections from the anomaly list, while rejecting the maximum number of anomalies arising from non-ordnance items. EFFICIENCY measures the fraction of detected ordnance retained after discrimination, while the REJECTION RATIO measures the fraction of false alarms rejected. Both measures are defined relative to performance at the demonstrator-supplied level below which all responses are considered noise, i.e., the maximum ordnance detectable by the sensor and its accompanying false positive rate or background alarm rate.

e. All scoring factors are generated utilizing the Standardized UXO Probability and Plot Program, version 3.1.1.

1.2.2 Scoring Factors

Factors to be measured and evaluated as part of this demonstration include:

a. Response Stage ROC curves:

(1) Probability of Detection (P_d^{res}).

(2) Probability of False Positive (P_{fp}^{res}).

(3) Background Alarm Rate (BAR^{res}) or Probability of Background Alarm (P_{BA}^{res}).

b. Discrimination Stage ROC curves:

(1) Probability of Detection (P_d^{disc}).

(2) Probability of False Positive (P_{fp}^{disc}).

(3) Background Alarm Rate (BAR^{disc}) or Probability of Background Alarm (P_{BA}^{disc}).

c. Metrics:

(1) Efficiency (E).

(2) False Positive Rejection Rate (R_{fp}).

(3) Background Alarm Rejection Rate (R_{BA}).

d. Other:

(1) Probability of Detection by Size and Depth.

(2) Classification by type (i.e., 20-mm, 40-mm, 105-mm, etc.).

(3) Location accuracy.

(4) Equipment setup, calibration time and corresponding man-hour requirements.

(5) Survey time and corresponding man-hour requirements.

(6) Reacquisition/resurvey time and man-hour requirements (if any).

(7) Downtime due to system malfunctions and maintenance requirements.

1.3 STANDARD AND NONSTANDARD INERT ORDNANCE TARGETS

The standard and nonstandard ordnance items emplaced in the test areas are listed in Table 1. Standardized targets are members of a set of specific ordnance items that have identical properties to all other items in the set (caliber, configuration, size, weight, aspect ratio, material, filler, magnetic remanence, and nomenclature). Nonstandard targets are ordnance items having properties that differ from those in the set of standardized targets.

TABLE 1. INERT ORDNANCE TARGETS

Standard Type	Nonstandard (NS)
20-mm Projectile M55	20-mm Projectile M55
	20-mm Projectile M97
40-mm Grenades M385	40-mm Grenades M385
40-mm Projectile MKII Bodies	40-mm Projectile M813
BDU-28 Submunition	
BLU-26 Submunition	
M42 Submunition	
57-mm Projectile APC M86	
60-mm Mortar M49A3	60-mm Mortar (JPG)
	60-mm Mortar M49
2.75-inch Rocket M230	2.75-inch Rocket M230
	2.75-inch Rocket XM229
MK 118 ROCKEYE	
81-mm Mortar M374	81-mm Mortar (JPG)
	81-mm Mortar M374
105-mm Heat Rounds M456	
105-mm Projectile M60	105-mm Projectile M60
155-mm Projectile M483A1	155-mm Projectile M483A
	500-lb Bomb
	M75 Submunition

JPG = Jefferson Proving Ground.

SECTION 2. DEMONSTRATION

2.1 DEMONSTRATOR INFORMATION

2.1.1 Demonstrator Point of Contact (POC) and Address

POC: Mr. Don Yule
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Address: U.S. Army Corps of Engineers Engineering Research and Development Center
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2.1.2 System Description (provided by demonstrator)

The TM 4 is a sophisticated magnetometer system that was developed by G-TEK and its predecessor, the Geophysical Research Institute, over a period of 15 years. The TM-4 has been designed for deployment from a number of terrestrial, marine, and airborne survey platforms and can be configured to include differential Global Positioning Systems (DGPS) for navigation, as well as, digital compensation for heading, pitch, and roll interference from a survey vehicle. It consists of data acquisition and detector control system and one or more optically-pumped magnetic sensors. The individual components of the system and the field operation are described in the following paragraphs.

The TM 4 controller (fig. 1) is a 32-bit computer based on a 12.5 MHz Motorola 68030 CPU and a Motorola 68331 floating-point coprocessor. The standard memory of 6MB in the TM 4 had the capacity for over a million data points. The data acquisition software is based on a proprietary, preemptive multi-tasking operating system designed specifically for high-speed data acquisition.

In hand-held operation along straight grid lines, automatic data acquisition was controlled by an in-built cotton thread odometer that provided an electronic pulse to the controller at 0.05 m intervals. The data logging system was interactive and permitted the operator to permanently record notes related to geological observations of significance and cultural features such as fences or scrap metal. At the end of a survey the information facilitates the automatic generation of geological and/or cultural feature maps that often provided an invaluable aid to data interpretation.

Optically-pumped, alkali vapor magnetic sensors were developed, based on helium and a number of alkali metal vapors which included potassium, rubidium and cesium. However, the most common commercially available sensors use cesium. The sensors used with the TM 4 include the G-822A (EG&G Geometrics, 1992) (fig. 1) and the CS-2 (Scintrex, 1993a) cesium vapor magnetic sensors.

At YPG, the positioning for the magnetometer was provided by a Trimble 5700 RTK Global Positioning System (GPS). This system is the state-of-the-art in GPS positioning and has consistently enabled G-TEK to achieve positional accuracies at the centimeter level.

Figure 1. Demonstrator's system, the TM-4 man portable.

2.1.3 Data Processing Description (provided by demonstrator)

The TM-4 will be operated as a two-person system. The person in front will carry the sensor frame, ensuring that a constant height and yaw angle is maintained throughout the survey. They are connected to the second person controlling that data-acquisition system, by an umbilical cord (fig. 1). Where practical, the TM-4 will be operated in quad-sensor configuration with four magnetometers separated by one foot. If the terrain conditions are sufficiently adverse the frame can be reduced in size and operated as a dual-sensor system.

Magnetometer data will be collected along parallel transects separated by 1 meter. This will cause adjacent lines to overlap slightly and will ensure that even if the operator deviates off their intended path, full coverage should still be achieved. The TM-4 will continuously record magnetometer data at a sample rate of 10 Hz. With the intended maximum walking speed of 1 m/s, this will ensure that the along-line sampling rate will be 10 cm at most. The

magnetometer readings are written to the TM-4 in a proprietary American Standard Code for Information Interchange (ASCII) format. A 1 PPS pulse from the GPS unit is also written to this file and is used to provide accurate timing of the magnetometer readings.

The GPS data (NMEA GGA and ZDA strings) are logged by a hand-held Norand computer at 1 Hz in a combination of ASCII and binary formats using G-TEK Australia's proprietary software (SurvNav). The GPS data along with the base-station data will also be recorded by the Trimble system as a backup in case problems occur with the real-time positioning. To ensure that the sensors remain on track as much as possible, survey chains and traffic cones will be used to mark the beginning and end of each line (and may also be placed at 25 meter intervals within the survey area).

During the survey a proton-procession magnetometer will be positioned in a fixed location and will record magnetic field measurements once every five seconds. This will allow temporal variations in magnetic field to be eliminated from the survey data.

2.1.4 Data Submission Format

Data were submitted for scoring in accordance with data submission protocols outlined in the Standardized UXO Technology Demonstration Site Handbook. These submitted data are not included in this report in order to protect ground truth information.

2.1.5 Demonstrator Quality Assurance (QA) and Quality Control (QC) (provided by demonstrator)

Quality measurements and control were monitored throughout all stages of data acquisition and processing. Listed below are the various facilities and procedures available to the operators to ensure that auditable quality was maintained with maximum data acquisition efficiency (negligible re-survey requirement).

a. DGPS Position and Coordinates.

(1) Having established the base station at a known monument of the highest order available, the GPS was taken to other known points in the survey area and the position of these points was determined using the roving DGPS receiver. Using this procedure, the map coordinate system and reference were confirmed to be correct. This procedure was repeated daily.

(2) Prior to every survey session using DGPS, a short magnetic survey traverse was performed crossing a known, localized, surface magnetic source from each of two opposite directions. The position of the source was also measured at this time. From this data, a processing check routine enabled the appropriate sensor offset from the GPS antenna.

(3) Throughout data acquisition, the DGPS quality was monitored by the display of resolution parameters such as number of satellites, receipt of differential corrections, and horizontal position accuracy.

b. Magnetometer Performance.

(1) The field value and root mean square (RMS) noise over a one second period was displayed for each sensor. A magnetic object was passed by each sensor in turn at the commencement of each survey session to check that the sensors were connected in the correct sequence.

(2) With the sensors stationary and the mains interference filter switched off, the condition of each sensor was determined and the amplitude of electromagnetic interference measured. Where electrical interference was encountered a low-pass filter at 25 Hz was turned on. In severe cases, this filter was applied twice increasing the attenuation but introducing a 150 m/s time delay. This delay (in effect 150 mm at 1m/s traverse speed) was removed through the lag correction procedure described in paragraph 2.1.4C.a.2 above.

(3) Because optically pumped type magnetometer sensors have an "active" and a "dead" zone of orientation relative to the Earth's magnetic field direction, the TM-4 was equipped with an audio and visual (red light) alarm that is activated if the Larmor signal from one or more sensors is lost. In most situations the error was corrected immediately with minimal data loss.

c. Quality Assurance procedures used after surveys were conducted.

(1) Prior to interpreting the recorded magnetic data, track-plots of the sensor position determined from the DGPS were produced and examined for any degradation that occurs, for example, when the GPS satellites are shielded by vegetation. Linear interpolation across such areas was performed if the distances affected were short. The separation between adjacent transects of data were checked to ensure that there were no parts of the survey area that are un-sampled. By using a line spacing that causes adjacent data collection traverses to overlap, such instances were avoided while paying particular attention to keeping the sensor frame online.

(2) Indicators of the GPS positioning accuracy, such as Position Dilution of Precision (PDOP) and the number of satellites, were displayed so that any areas with inaccurate positioning were identified. Where possible, these problems were corrected by post-processing the GPS data that were recorded within the Trimble GPS unit. Careful monitoring of the GPS accuracy in the field and storage of the raw GPS data prevented the need to resurvey areas.

d. A post processing routine automatically detected bad data that occurred when the magnetometer was in the dead-zone and this was documented in a processing report file. G-TEK Australia routinely over-sample along-line enabling the number of adjacent bad data points that were rejected without loss of detection performance to be defined (usually three points). Due to the alarm facility included in the TM-4, described in paragraph 2.1.4.C.c.2 above, the number of adjacent bad data rarely exceeded the over-sampling specification thereby obviating any need to resurvey.

2.1.6 Additional Records

The following record(s) by this vendor can be accessed via the Internet as MicroSoft Word documents at www.uxotestsites.org.

2.2 YPG SITE INFORMATION

2.2.1 Location

YPG is located adjacent to the Colorado River in the Sonoran Desert. The UXO Standardized Test Site is located south of Pole Line Road and east of the Countermine Testing and Training Range. The Open Field range, Calibration Grid, Blind Grid, Mogul area, and Desert Extreme area comprise the 350- by-500-meter general test site area. The open field site is the largest of the test sites and measures approximately 200-by-350 meters. To the east of the open field range are the calibration and blind test grids that measure 30-by-40 meters and 40 by 40 meters, respectively. South of the Open Field is the 135- by 80-meter Mogul area consisting of a sequence of man-made depressions. The Desert Extreme area is located southeast of the open field site and has dimensions of 50-by-100 meters. The Desert Extreme area, covered with desert-type vegetation, is used to test the performance of different sensor platforms in a more severe desert conditions/environment.

2.2.2 Soil Type

Soil samples were collected at the YPG UXO Standardized Test Site by ERDC to characterize the shallow subsurface (< 3 m). Both surface grab samples and continuous soil borings were acquired. The soils were subjected to several laboratory analyses, including sieve/hydrometer, water content, magnetic susceptibility, dielectric permittivity, X-ray diffraction, and visual description.

There are two soil complexes present within the site, Riverbend-Carrizo and Cristobal-Gunsight. The Riverbend-Carrizo complex is comprised of mixed stream alluvium, whereas the Cristobal-Gunsight complex is derived from fan alluvium. The Cristobal-Gunsight complex covers the majority of the site. Most of the soil samples were classified as either a sandy loam or loamy sand, with most samples containing gravel-size particles. All samples had the measured water content of less than 7 percent, except for two that contained 11-percent moisture. The majority of soil samples had water content between 1 to 2 percent. Samples containing more than 3 percent were generally deeper than 1 meter.

An X-ray diffraction analysis on four soil samples indicated a basic mineralogy of quartz, calcite, mica, feldspar, magnetite, and some clay. The presence of magnetite imparted a moderate magnetic susceptibility, with volume susceptibilities generally greater than 100 by 10-5 SI.

For more details concerning the soil properties at the YPG test site, go to www.uxotestsites.org on the web to view the entire soils description report.

2.2.3 Test Areas

A description of the test site areas at YPG is included in Table 2.

TABLE 2. TEST SITE AREAS

Area	Description
Calibration Grid	Contains the 15 standard ordnance items buried in six positions at various angles and depths to allow demonstrator equipment calibration.
Blind Grid	Contains 400 grid cells in a 0.16-hectare (0.39-acre) site. The center of each grid cell contains ordnance, clutter, or nothing.

SECTION 3. FIELD DATA

3.1 DATE OF FIELD ACTIVITIES: 12, 13, and 17 May 2003

3.2 AREAS TESTED/NUMBER OF HOURS

Areas tested and total numbers of hours operated at each site are summarized in Table 3.

TABLE 3. AREAS TESTED AND NUMBER OF HOURS

Area	Number of Hours
Calibration Lanes	4.25
Blind Grid	7.75

3.3 TEST CONDITIONS

3.3.1 Weather Conditions

A YPG weather station located approximately one mile west of the test site was used to record average temperature and precipitation on a half hour basis for each day of operation. The temperatures listed in Table 4 represent the average temperature during field operations from 0700 to 1700 hours while precipitation data represents a daily total amount of rainfall. Hourly weather logs used to generate this summary are provided in Appendix B.

TABLE 4. TEMPERATURE/PRECIPITATION DATA SUMMARY

Date, 2003	Average Temperature, °F	Total Daily Precipitation, in.
12 May	87.2	0.00
13 May	N\A	0.00
17 May	N\A	0.00

3.3.2 Field Conditions

The field conditions remained dry throughout the demonstration.

3.3.3 Soil Moisture

Three soil probes were placed at various locations within the site to capture soil moisture data: Calibration, Mogul, and Desert Extreme areas. Measurements were collected in percent moisture and were taken twice daily (morning and afternoon) from five different soil depths (1 to 6 in., 6 to 12 in., 12 to 24 in., 24 to 36 in., and 36 to 48 in.) from each probe. Soil moisture logs are included in Appendix C.

3.4 FIELD ACTIVITIES

3.4.1 Setup/Mobilization

These activities included initial mobilization and daily equipment preparation and breakdown. The three-person crew took 25 minutes to perform the initial setup and mobilization. There was 3 hours and 50 minutes of daily equipment preparation, with no time needed for end of the day equipment breakdowns.

3.4.2 Calibration

ERDC spend a total of 4 hours and 15 minutes in the calibration lanes, 2 hours and 25 minutes of which was spent collecting data.

3.4.3 Downtime Occasions

Occasions of downtime are grouped into five categories: equipment/data checks or equipment maintenance, equipment failure and repair, weather, Demonstration Site issues, or breaks/lunch. All downtime is included for the purposes of calculating labor costs (section 5) except for downtime due to Demonstration Site issues. Demonstration Site issues, while noted in the Daily Log, are considered non-chargeable downtime for the purposes of calculating labor costs and are not discussed. Breaks and lunches are included in this section and billed to the total Site Survey area.

3.4.3.1 Equipment/data checks, maintenance. Equipment/data checks and maintenance activities accounted for no time during this part of testing. These activities do include the changing out of batteries and routine data checks to ensure data were being properly recorded/collected. In addition, ERDC spend a total of 1-hour and 40 minutes for breaks and lunches.

3.4.3.2 Equipment failure or repair. No instances of equipment failure occurred while surveying the Blind Grid area.

3.4.3.3 Weather. No weather delays occurred during the survey.

3.4.4 Data Collection

ERDC spent a total time of 2 hours and 15 minutes in the Blind Grid area, all of which was spent collecting data.

3.4.5 Demobilization

The ERDC survey crew went on to conduct a full demonstration of the YPG site. Therefore, actual demobilization did not occur until 17 May 2003. On that day, it took the crew 15 minutes to break down and pack up their equipment.

3.5 PROCESSING TIME

ERDC submitted the raw data from the demonstration activities on the last day of the demonstration, as required. The scoring submittal data was also provided within the required 30-day timeframe.

3.6 DEMONSTRATOR'S FIELD PERSONNEL

Field Manager/Field Engineer:	Steve Billings
Quality Assurance:	Don Yule
GPS Support:	Tom Berry

3.7 DEMONSTRATOR'S FIELD SURVEYING METHOD

The Calibration Lanes was surveyed in four directions: NS, SN, EW, and WE. Then, repeated in the SN orientation to check for repeatability. The Blind Grid was surveyed in the exact same method.

3.8 SUMMARY OF DAILY LOGS

Daily logs capture all field activities during this demonstration and are located in Appendix D. Activities pertinent to this specific demonstration are indicated in highlighted text.

SECTION 4. TECHNICAL PERFORMANCE RESULTS

4.1 ROC CURVES USING ALL ORDNANCE CATEGORIES

Figure 2 shows the probability of detection for the response stage (P_d^{res}) and the discrimination stage (P_d^{disc}) versus their respective probability of false positive. Figure 3 shows both probabilities plotted against their respective probability of background alarm. Both figures use horizontal lines to illustrate the performance of the demonstrator at two demonstrator-specified points: at the system noise level for the response stage, representing the point below which targets are not considered detectable, and at the demonstrator's recommended threshold level for the discrimination stage, defining the subset of targets the demonstrator would recommend digging based on discrimination. Note that all points have been rounded to protect the ground truth.

The overall ground truth is composed of ferrous and non-ferrous anomalies. Due to limitations of the magnetometer, the non-ferrous items cannot be detected. Therefore, the ROC curves presented in this section are based on the subset of the ground truth that is solely made up of ferrous anomalies.

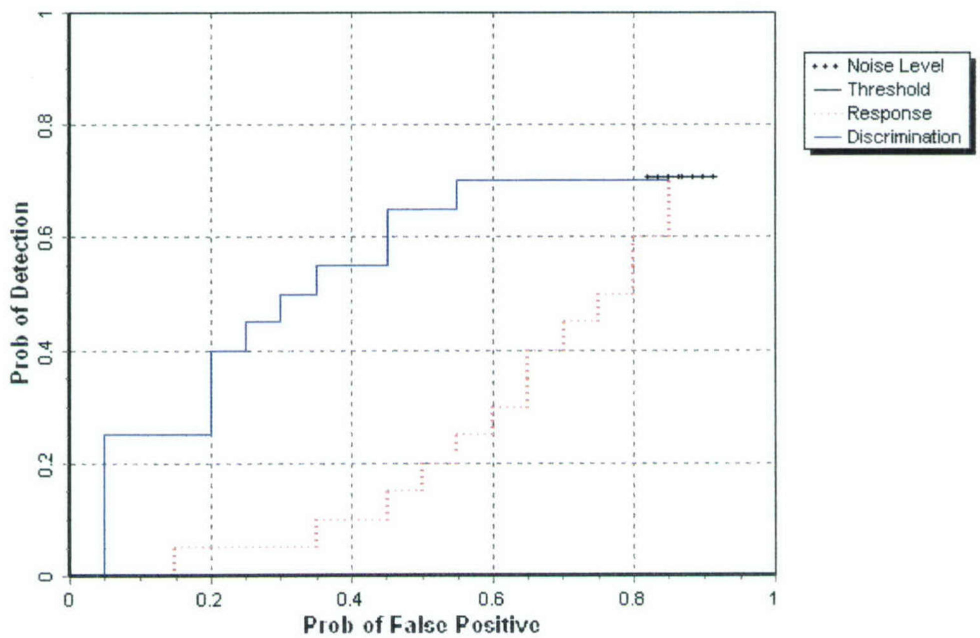

Figure 2. TM-4 blind grid probability of detection for response and discrimination stages versus their respective probability of false positive over all ordnance categories combined.

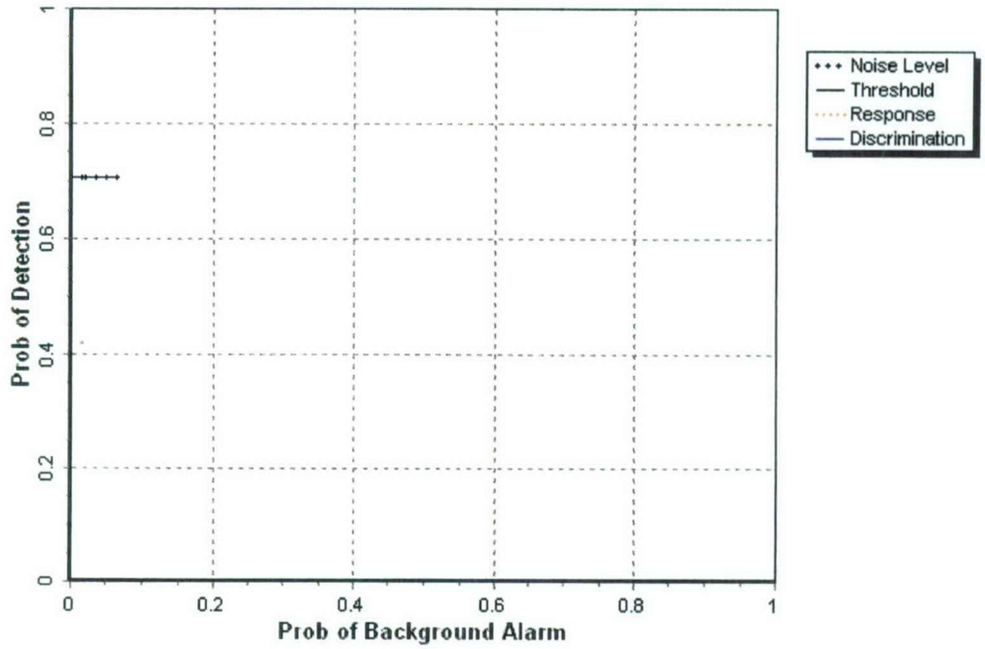

Figure 3. TM-4 blind grid probability of detection for response and discrimination stages versus their respective probability of background alarm over all ordnance categories combined.

4.2 ROC CURVES USING ORDNANCE LARGER THAN 20 MM

Figure 4 shows the probability of detection for the response stage (P_d^{res}) and the discrimination stage (P_d^{disc}) versus their respective probability of false positive when only targets larger than 20 mm are scored. Figure 5 shows both probabilities plotted against their respective probability of background alarm. Both figures use horizontal lines to illustrate the performance of the demonstrator at two demonstrator-specified points: at the system noise level for the response stage, representing the point below which targets are not considered detectable, and at the demonstrator's recommended threshold level for the discrimination stage, defining the subset of targets the demonstrator would recommend digging based on discrimination. Note that all points have been rounded to protect the ground truth.

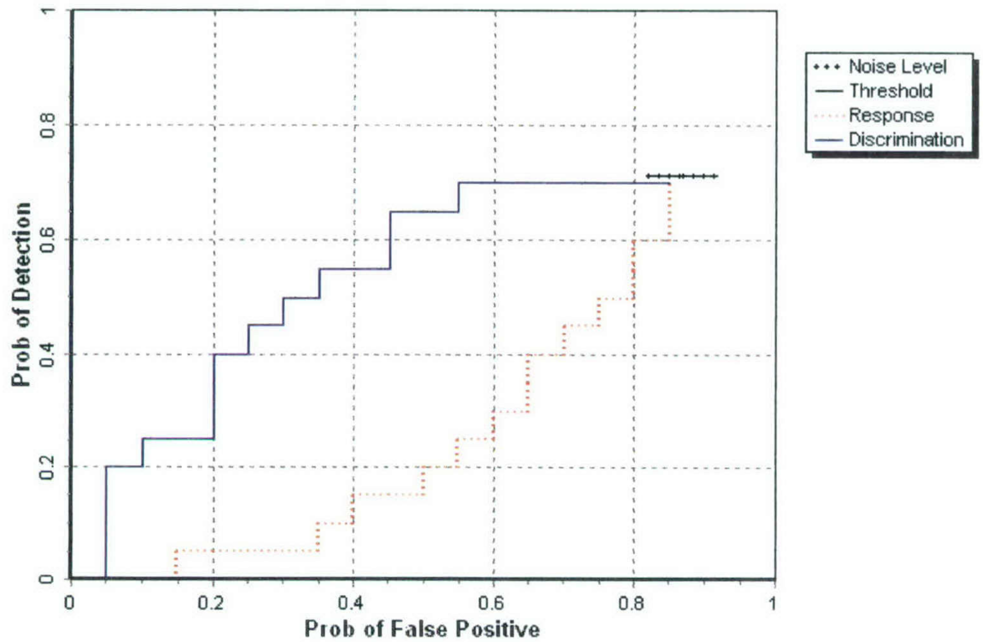

Figure 4. TM-4 blind grid probability of detection for response and discrimination stages versus their respective probability of false positive for all ordnance larger than 20 mm.

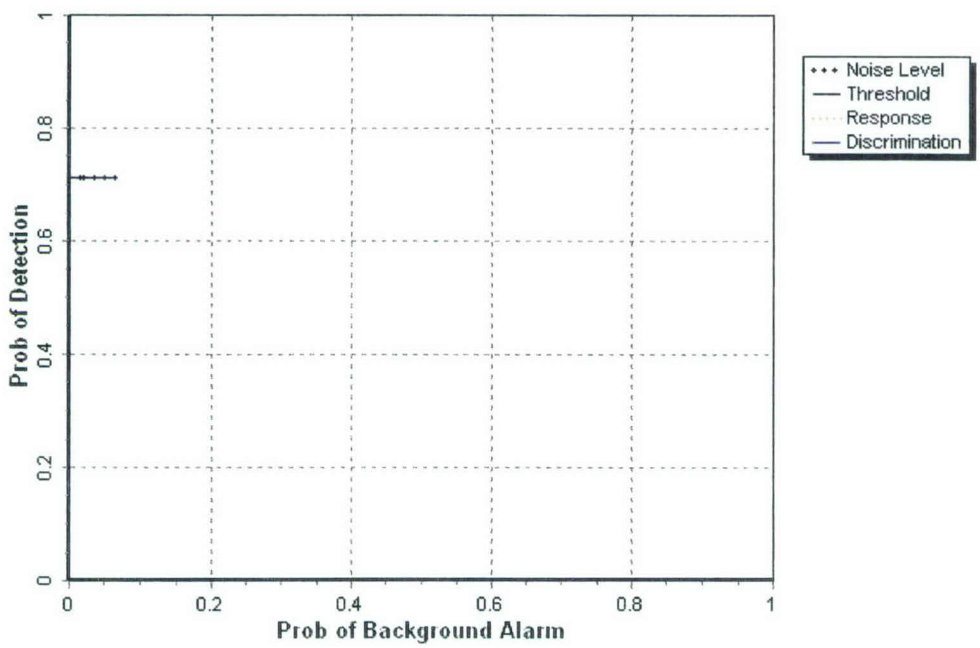

Figure 5. TM-4 blind grid probability of detection for response and discrimination stages versus their respective probabilities of background alarm for all ordnance larger than 20 mm.

4.3 PERFORMANCE SUMMARIES

Results for the Blind Grid test, broken out by size, depth and nonstandard ordnance, are presented in Table 5a and 5b (for cost results, see section 5). Results by size and depth include both standard and nonstandard ordnance. The results by size show how well the demonstrator did at detecting/discriminating ordnance of a certain caliber range (see app A for size definitions). The results are relative to the number of ordnances emplaced. Depth is measured from the geometeric center of anomolies.

The RESPONSE STAGE results are derived from the list of anomalies above the demonstrator-provided noise level. The results for the DISCRIMINATION STAGE are derived from the demonstrator's recommended threshold for optimizing UXO field cleanup by minimizing false digs and maximizing ordnance recovery. The lower 90-percent confidence limit on probability of detection and probability of false positive was calculated assuming that the number of detections and false positives are binomially distributed random variables. All results in Table 5a and 5b have been rounded to protect the ground truth. However, lower confidence limits were calculated using actual results.

The overall ground truth is composed of ferrous and non-ferrous anomalies. Due to limitations of the magnetometer, the non-ferrous items cannot be detected. Therefore, the summary presented in Table 5a exhibits results based on the subset of the ground truth that is solely the ferrous anomalies. Table 5b exhibits results based on the full ground truth. All other tables presented in this section are based on scoring against the ferrous only ground truth. The response stage noise level and recommended discrimination stage threshold values are provided by the demonstrator.

TABLE 5a. SUMMARY OF BLIND GRID RESULTS (FERROUS ONLY)

Metric	Overall	Standard	Nonstandard	By Size			By Depth, m		
				Small	Medium	Large	< 0.3	0.3 to <1	>= 1
RESPONSE STAGE									
P_d	0.70	0.70	0.70	0.60	0.80	0.80	0.70	0.80	0.45
P_d Low 90% Conf	0.62	0.60	0.56	0.47	0.63	0.58	0.58	0.67	0.17
P_d Upper 90% Conf	0.78	0.81	0.82	0.73	0.89	0.92	0.80	0.92	0.72
P_{fp}	0.85	-	-	-	-	-	0.85	0.90	N/A
P_{fp} Low 90% Conf	0.82	-	-	-	-	-	0.80	0.78	-
P_d Upper 90% Conf	0.91	-	-	-	-	-	0.91	0.96	-
P_{ba}	0.00	-	-	-	-	-	-	-	-
DISCRIMINATION STAGE									
P_d	0.70	0.70	0.70	0.60	0.80	0.80	0.70	0.80	0.45
P_d Low 90% Conf	0.62	0.60	0.56	0.47	0.63	0.58	0.58	0.67	0.17
P_d Upper 90% Conf	0.78	0.81	0.82	0.73	0.89	0.92	0.80	0.92	0.72
P_{fp}	0.85	-	-	-	-	-	0.85	0.90	N/A
P_{fp} Low 90% Conf	0.82	-	-	-	-	-	0.80	0.78	-
P_d Upper 90% Conf	0.91	-	-	-	-	-	0.91	0.96	-
P_{ba}	0.00	-	-	-	-	-	-	-	-

Response Stage Noise Level: 11.03.
Recommended Discrimination Stage Threshold: 0.05.

TABLE 5b. SUMMARY OF BLIND GRID RESULTS (FULL GROUND TRUTH)

Metric	Overall	Standard	Nonstandard	By Size			By Depth, m		
				Small	Medium	Large	< 0.3	0.3 to <1	>= 1
RESPONSE STAGE									
P_d	0.65	0.60	0.70	0.50	0.80	0.80	0.60	0.75	0.45
P_d Low 90% Conf	0.55	0.49	0.55	0.37	0.63	0.58	0.50	0.60	0.17
P_d Upper 90% Conf	0.71	0.70	0.80	0.60	0.89	0.92	0.71	0.86	0.72
P_{fp}	0.85	-	-	-	-	-	0.85	0.90	N/A
P_{fp} Low 90% Conf	0.82	-	-	-	-	-	0.80	0.78	-
P_d Upper 90% Conf	0.91	-	-	-	-	-	0.91	0.96	-
P_{ba}	0.00	-	-	-	-	-	-	-	-
DISCRIMINATION STAGE									
P_d	0.65	0.60	0.70	0.50	0.80	0.80	0.60	0.75	0.45
P_d Low 90% Conf	0.55	0.49	0.55	0.37	0.63	0.58	0.50	0.60	0.17
P_d Upper 90% Conf	0.71	0.70	0.80	0.60	0.89	0.92	0.71	0.86	0.72
P_{fp}	0.85	-	-	-	-	-	0.85	0.90	N/A
P_{fp} Low 90% Conf	0.82	-	-	-	-	-	0.80	0.78	-
P_d Upper 90% Conf	0.91	-	-	-	-	-	0.91	0.96	-
P_{ba}	0.00	-	-	-	-	-	-	-	-

Response Stage Noise Level: 11.03.
Recommended Discrimination Stage Threshold 0.50.

Note: The recommended discrimination stage threshold values are provided by the demonstrator. No discrimination algorithm was applied. Therefore, the response and discrimination stage results are exactly the same.

4.4 EFFICIENCY, REJECTION RATES, AND TYPE CLASSIFICATION

Efficiency and rejection rates are calculated to quantify the discrimination ability at specific points of interest on the ROC curve: (1) at the point where no decrease in P_d is suffered (i.e., the efficiency is by definition equal to one) and (2) at the operator selected threshold. These values are reported in Table 6.

TABLE 6. EFFICIENCY AND REJECTION RATES

	Efficiency (E)	False Positive Rejection Rate	Background Alarm Rejection Rate
At Operating Point	1.00	0.00	0.00
With No Loss of P_d	1.00	0.09	0.00

At the demonstrator's recommended setting, the ordnance items that were detected and correctly discriminated were further scored on whether their correct type could be identified (table 8). Correct type examples include "20-mm projectile, 105-mm HEAT Projectile, and 2.75-inch Rocket". A list of the standard type declaration required for each ordnance item was provided to demonstrators prior to testing. For example, the standard type for the three example items are 20mmP, 105H, and 2.75in, respectively.

TABLE 7. CORRECT TYPE CLASSIFICATION OF TARGETS CORRECTLY DISCRIMINATED AS UXO

Size	Percentage Correct
Small	0.00
Medium	0.00
Large	0.00
Overall	0.00

Note: The demonstrator did not attempt to provide type classification.

4.5 LOCATION ACCURACY

The mean location error and standard deviations appear in Table 8. These calculations are based on average missed depth for ordnance correctly identified in the discrimination stage. Depths are measured from the closest point of the ordnance to the surface. For the Blind Grid, only depth errors are calculated, since (X, Y) positions are known to be the centers of each grid square.

TABLE 8. MEAN LOCATION ERROR AND STANDARD DEVIATION (M)

	Mean	Standard Deviation
Depth	-0.39	0.33

SECTION 5. ON-SITE LABOR COSTS

A standardized estimate for labor costs associated with this effort was calculated as follows: the first person at the test site was designated "supervisor", the second person was designated "data analyst", and the third and following personnel were considered "field support". Standardized hourly labor rates were charged by title: supervisor at $95.00/hour, data analyst at $57.00/hour, and field support at $28.50/hour.

Government representatives monitored on-site activity. All on-site activities were grouped into one of ten categories: initial setup/mobilization, daily setup/stop, calibration, collecting data, downtime due to break/lunch, downtime due to equipment failure, downtime due to equipment/data checks or maintenance, downtime due to weather, downtime due to demonstration site issue, or demobilization. See Appendix D for the daily activity log. See section 3.4 for a summary of field activities.

The standardized cost estimate associated with the labor needed to perform the field activities is presented in Table 9. Note that calibration time includes time spent in the Calibration Lanes as well as field calibrations. "Site survey time" includes daily setup/stop time, collecting data, breaks/lunch, downtime due to equipment/data checks or maintenance, downtime due to failure, and downtime due to weather.

TABLE 9. ON-SITE LABOR COSTS

	No. People	Hourly Wage	Hours	Cost
Initial Setup				
Supervisor	1	$95.00	0.42	$39.90
Data Analyst	1	57.00	0.42	23.94
Field Support	1	28.50	0.42	11.97
SubTotal				**$75.81**
Calibration				
Supervisor	1	$95.00	4.25	$403.75
Data Analyst	1	57.00	4.25	242.25
Field Support	1	28.50	4.25	121.13
SubTotal				**$767.13**
Site Survey				
Supervisor	1	$95.00	7.75	$736.25
Data Analyst	1	57.00	7.75	441.75
Field Support	1	28.50	7.75	220.88
SubTotal				**$1,398.88**

See notes at end of table.

TABLE 9 (CONT'D)

	No. People	Hourly Wage	Hours	Cost
Demobilization				
Supervisor	1	$95.00	0.25	$23.75
Data Analyst	1	57.00	0.25	14.25
Field Support	1	28.50	0.25	7.13
Subtotal				**$45.13**
Total				**$2,286.95**

Notes: Calibration time includes time spent in the Calibration Lanes as well as calibration before each data run.

Site Survey time includes daily setup/stop time, collecting data, breaks/lunch, downtime due to system maintenance, failure, and weather.

SECTION 6. COMPARISON OF RESULTS TO DATE

No comparisons to date.

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SECTION 7. APPENDIXES

APPENDIX A. TERMS AND DEFINITIONS

GENERAL DEFINITIONS

Anomaly: Location of a system response deemed to warrant further investigation by the demonstrator for consideration as an emplaced ordnance item.

Detection: An anomaly location that is within R_{halo} of an emplaced ordnance item.

Emplaced Ordnance: An ordnance item buried by the government at a specified location in the test site.

Emplaced Clutter: A clutter item (i.e., non-ordnance item) buried by the government at a specified location in the test site.

R_{halo}: A pre-determined radius about the periphery of an emplaced item (clutter or ordnance) within which a location identified by the demonstrator as being of interest is considered to be a response from that item. If multiple declarations lie within R_{halo} of any item (clutter or ordnance), the declaration with the highest signal output within the R_{halo} will be utilized. For the purpose of this program, a circular halo 0.5 meters in radius will be placed around the center of the object for all clutter and ordnance items less than 0.6 meters in length. When ordnance items are longer than 0.6 meters, the halo becomes an ellipse where the minor axis remains 1 meter and the major axis is equal to the length of the ordnance plus 1 meter.

Small Ordnance: Caliber of ordnance less than or equal to 40-mm (includes 20-mm projectile, 40-mm projectile, submunitions BLU-26, BLU-63, and M42).

Medium Ordnance: Caliber of ordnance greater than 40-mm and less than or equal to 81-mm (includes 57-mm projectile, 60-mm mortar, 2.75 in. Rocket, MK118 Rockeye, 81-mm mortar).

Large Ordnance: Caliber of ordnance greater than 81-mm (includes 105-mm HEAT, 105-mm projectile, 155-mm projectile, 500-pound bomb).

Shallow: Items buried less than 0.3 meter below ground surface.

Medium: Items buried greater than or equal to 0.3 meter and less than 1 meter below ground surface.

Deep: Items buried greater than or equal to 1 meter below ground surface.

Response Stage Noise Level: The level that represents the point below which anomalies are not considered detectable. Demonstrators are required to provide the recommended noise level for the Blind Grid test area.

Discrimination Stage Threshold: The demonstrator selected threshold level that they believe provides optimum performance of the system by retaining all detectable ordnance and rejecting the maximum amount of clutter. This level defines the subset of anomalies the demonstrator would recommend digging based on discrimination.

Binomially Distributed Random Variable: A random variable of the type which has only two possible outcomes, say success and failure, is repeated for n independent trials with the probability p of success and the probability 1-p of failure being the same for each trial. The number of successes x observed in the n trials is an estimate of p and is considered to be a binomially distributed random variable.

RESPONSE AND DISCRIMINATION STAGE DATA

The scoring of the demonstrator's performance is conducted in two stages. These two stages are termed the RESPONSE STAGE and DISCRIMINATION STAGE. For both stages, the probability of detection (P_d) and the false alarms are reported as receiver-operating characteristic (ROC) curves. False alarms are divided into those anomalies that correspond to emplaced clutter items, measuring the probability of false positive (P_{fp}) and those that do not correspond to any known item, termed background alarms.

The RESPONSE STAGE scoring evaluates the ability of the system to detect emplaced targets without regard to ability to discriminate ordnance from other anomalies. For the RESPONSE STAGE, the demonstrator provides the scoring committee with the location and signal strength of all anomalies that the demonstrator has deemed sufficient to warrant further investigation and/or processing as potential emplaced ordnance items. This list is generated with minimal processing (e.g., this list will include all signals above the system noise threshold). As such, it represents the most inclusive list of anomalies.

The DISCRIMINATION STAGE evaluates the demonstrator's ability to correctly identify ordnance as such, and to reject clutter. For the same locations as in the RESPONSE STAGE anomaly list, the DISCRIMINATION STAGE list contains the output of the algorithms applied in the discrimination-stage processing. This list is prioritized based on the demonstrator's determination that an anomaly location is likely to contain ordnance. Thus, higher output values are indicative of higher confidence that an ordnance item is present at the specified location. For electronic signal processing, priority ranking is based on algorithm output. For other systems, priority ranking is based on human judgment. The demonstrator also selects the threshold that the demonstrator believes will provide "optimum" system performance, (i.e., that retains all the detected ordnance and rejects the maximum amount of clutter).

Note: The two lists provided by the demonstrator contain identical numbers of potential target locations. They differ only in the priority ranking of the declarations.

RESPONSE STAGE DEFINITIONS

Response Stage Probability of Detection (P_d^{res}): P_d^{res} = (No. of response-stage detections)/(No. of emplaced ordnance in the test site).

Response Stage False Positive (fp^{res}): An anomaly location that is within R_{halo} of an emplaced clutter item.

Response Stage Probability of False Positive (P_{fp}^{res}): P_{fp}^{res} = (No. of response-stage false positives)/(No. of emplaced clutter items).

Response Stage Background Alarm (ba^{res}): An anomaly in a blind grid cell that contains neither emplaced ordnance nor an emplaced clutter item. An anomaly location in the open field or scenarios that is outside R_{halo} of any emplaced ordnance or emplaced clutter item.

Response Stage Probability of Background Alarm (P_{ba}^{res}): Blind Grid only: P_{ba}^{res} = (No. of response-stage background alarms)/(No. of empty grid locations).

Response Stage Background Alarm Rate (BAR^{res}): Open Field only: BAR^{res} = (No. of response-stage background alarms)/(arbitrary constant).

Note that the quantities P_d^{res}, P_{fp}^{res}, P_{ba}^{res}, and BAR^{res} are functions of t^{res}, the threshold applied to the response-stage signal strength. These quantities can therefore be written as $P_d^{res}(t^{res})$, $P_{fp}^{res}(t^{res})$, $P_{ba}^{res}(t^{res})$, and $BAR^{res}(t^{res})$.

DISCRIMINATION STAGE DEFINITIONS

Discrimination: The application of a signal processing algorithm or human judgment to response-stage data that discriminates ordnance from clutter. Discrimination should identify anomalies that the demonstrator has high confidence correspond to ordnance, as well as those that the demonstrator has high confidence correspond to non-ordnance or background returns. The former should be ranked with highest priority and the latter with lowest.

Discrimination Stage Probability of Detection (P_d^{disc}): P_d^{disc} = (No. of discrimination-stage detections)/(No. of emplaced ordnance in the test site).

Discrimination Stage False Positive (fp^{disc}): An anomaly location that is within R_{halo} of an emplaced clutter item.

Discrimination Stage Probability of False Positive (P_{fp}^{disc}): P_{fp}^{disc} = (No. of discrimination stage false positives)/(No. of emplaced clutter items).

Discrimination Stage Background Alarm (ba^{disc}): An anomaly in a blind grid cell that contains neither emplaced ordnance nor an emplaced clutter item. An anomaly location in the open field or scenarios that is outside R_{halo} of any emplaced ordnance or emplaced clutter item.

Discrimination Stage Probability of Background Alarm (P_{ba}^{disc}): P_{ba}^{disc} = (No. of discrimination-stage background alarms)/(No. of empty grid locations).

Discrimination Stage Background Alarm Rate (BAR^{disc}): BAR^{disc} = (No. of discrimination-stage background alarms)/(arbitrary constant).

Note that the quantities P_d^{disc}, P_{fp}^{disc}, P_{ba}^{disc}, and BAR^{disc} are functions of t^{disc}, the threshold applied to the discrimination-stage signal strength. These quantities can therefore be written as $P_d^{disc}(t^{disc})$, $P_{fp}^{disc}(t^{disc})$, $P_{ba}^{disc}(t^{disc})$, and $BAR^{disc}(t^{disc})$.

RECEIVER-OPERATING CHARACERISTIC (ROC) CURVES

ROC curves at both the response and discrimination stages can be constructed based on the above definitions. The ROC curves plot the relationship between P_d versus P_{fp} and P_d versus BAR or P_{ba} as the threshold applied to the signal strength is varied from its minimum (t_{min}) to its maximum (t_{max}) value.[1] Figure A-1 shows how P_d versus P_{fp} and P_d versus BAR are combined into ROC curves. Note that the "res" and "disc" superscripts have been suppressed from all the variables for clarity.

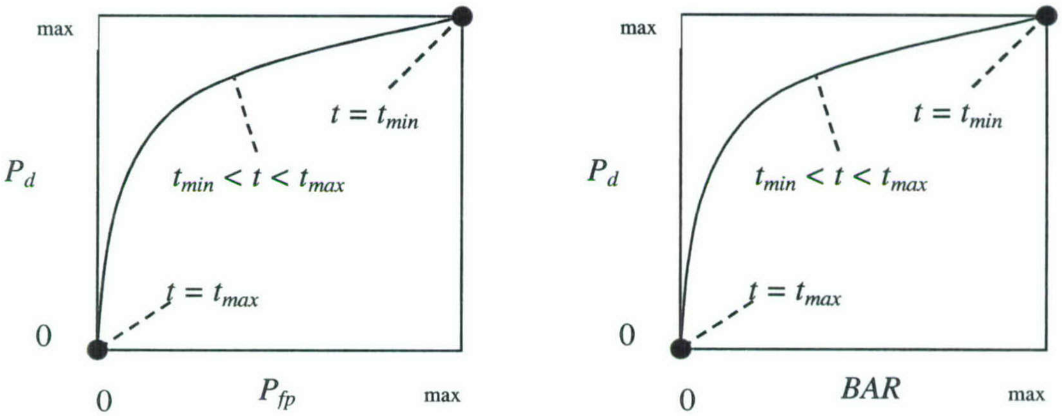

Figure A-1. ROC curves for open field-testing. Each curve applies to both the response and discrimination stages.

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[1]Strictly speaking, ROC curves plot the P_d versus P_{ba} over a pre-determined and fixed number of detection opportunities (some of the opportunities are located over ordnance and others are located over clutter or blank spots). In an open field scenario, each system suppresses its signal strength reports until some bare-minimum signal response is received by the system. Consequently, the open field ROC curves do not have information from low signal-output locations, and, furthermore, different contractors report their signals over a different set of locations on the ground. These ROC curves are thus not true to the strict definition of ROC curves as defined in textbooks on detection theory. Note, however, that the ROC curves obtained in the Blind Grid test sites are true ROC curves.

METRICS TO CHARACTERIZE THE DISCRIMINATION STAGE

The demonstrator is also scored on efficiency and rejection ratio, which measure the effectiveness of the discrimination stage processing. The goal of discrimination is to retain the greatest number of ordnance detections from the anomaly list, while rejecting the maximum number of anomalies arising from non-ordnance items. The efficiency measures the amount of detected ordnance retained by the discrimination, while the rejection ratio measures the fraction of false alarms rejected. Both measures are defined relative to the entire response list, i.e., the maximum ordnance detectable by the sensor and its accompanying false positive rate or background alarm rate.

Efficiency (E): $E = P_d^{disc}(t^{disc})/P_d^{res}(t_{min}^{res})$; Measures (at a threshold of interest), the degree to which the maximum theoretical detection performance of the sensor system (as determined by the response stage tmin) is preserved after application of discrimination techniques. Efficiency is a number between 0 and 1. An efficiency of 1 implies that all of the ordnance initially detected in the response stage was retained at the specified threshold in the discrimination stage, t^{disc}.

False Positive Rejection Rate (R_{fp}): $R_{fp} = 1 - [P_{fp}^{disc}(t^{disc})/P_{fp}^{res}(t_{min}^{res})]$; Measures (at a threshold of interest), the degree to which the sensor system's false positive performance is improved over the maximum false positive performance (as determined by the response stage tmin). The rejection rate is a number between 0 and 1. A rejection rate of 1 implies that all emplaced clutter initially detected in the response stage were correctly rejected at the specified threshold in the discrimination stage.

Background Alarm Rejection Rate (R_{ba}):

Blind Grid: $R_{ba} = 1 - [P_{ba}^{disc}(t^{disc})/P_{ba}^{res}(t_{min}^{res})]$.
Open Field: $R_{ba} = 1 - [BAR^{disc}(t^{disc})/BAR^{res}(t_{min}^{res})]$).

Measures the degree to which the discrimination stage correctly rejects background alarms initially detected in the response stage. The rejection rate is a number between 0 and 1. A rejection rate of 1 implies that all background alarms initially detected in the response stage were rejected at the specified threshold in the discrimination stage.

CHI-SQUARE COMPARISON EXPLANATION:

The Chi-square test for differences in probabilities (or 2 x 2 contingency table) is used to analyze two samples drawn from two different populations to see if both populations have the same or different proportions of elements in a certain category. More specifically, two random samples are drawn, one from each population, to test the null hypothesis that the probability of event A (some specified event) is the same for both populations (ref 4).

A 2 x 2 contingency table is used in the Standardized UXO Technology Demonstration Site Program to determine if there is reason to believe that the proportion of ordnance correctly detected/discriminated by demonstrator X's system is significantly degraded by the more

challenging terrain feature introduced. The test statistic of the 2 x 2 contingency table is the Chi-square distribution with one degree of freedom. Since an association between the more challenging terrain feature and relatively degraded performance is sought, a one-sided test is performed. A significance level of 0.05 is chosen which sets a critical decision limit of 2.71 from the Chi-square distribution with one degree of freedom. It is a critical decision limit because if the test statistic calculated from the data exceeds this value, the two proportions tested will be considered significantly different. If the test statistic calculated from the data is less than this value, the two proportions tested will be considered not significantly different.

An exception must be applied when either a 0 or 100 percent success rate occurs in the sample data. The Chi-square test cannot be used in these instances. Instead, Fischer's test is used and the critical decision limit for one-sided tests is the chosen significance level, which in this case is 0.05. With Fischer's test, if the test statistic is less than the critical value, the proportions are considered to be significantly different.

Standardized UXO Technology Demonstration Site examples, where blind grid results are compared to those from the open field and open field results are compared to those from one of the scenarios, follow. It should be noted that a significant result does not prove a cause and effect relationship exists between the two populations of interest; however, it does serve as a tool to indicate that one data set has experienced a degradation in system performance at a large enough level than can be accounted for merely by chance or random variation. Note also that a result that is not significant indicates that there is not enough evidence to declare that anything more than chance or random variation within the same population is at work between the two data sets being compared.

Demonstrator X achieves the following overall results after surveying each of the three progressively more difficult areas using the same system (results indicate the number of ordnance detected divided by the number of ordnance emplaced):

	Blind Grid	Open Field	Moguls
P_d^{res}	100/100 = 1.0	8/10 = .80	20/33 = .61
P_d^{disc}	80/100 = 0.80	6/10 = .60	8/33 = .24

P_d^{res}: BLIND GRID versus OPEN FIELD. Using the example data above to compare probabilities of detection in the response stage, all 100 ordnance out of 100 emplaced ordnance items were detected in the blind grid while 8 ordnance out of 10 emplaced were detected in the open field. Fischer's test must be used since a 100 percent success rate occurs in the data. Fischer's test uses the four input values to calculate a test statistic of 0.0075 that is compared against the critical value of 0.05. Since the test statistic is less than the critical value, the smaller response stage detection rate (0.80) is considered to be significantly less at the 0.05 level of significance. While a significant result does not prove a cause and effect relationship exists between the change in survey area and degradation in performance, it does indicate that the detection ability of demonstrator X's system seems to have been degraded in the open field relative to results from the blind grid using the same system.

P_d^{disc}: BLIND GRID versus OPEN FIELD. Using the example data above to compare probabilities of detection in the discrimination stage, 80 out of 100 emplaced ordnance items were correctly discriminated as ordnance in blind grid testing while 6 ordnance out of 10 emplaced were correctly discriminated as such in open field testing. Those four values are used to calculate a test statistic of 1.12. Since the test statistic is less than the critical value of 2.71, the two discrimination stage detection rates are considered to be not significantly different at the 0.05 level of significance.

P_d^{res}: OPEN FIELD versus MOGULS. Using the example data above to compare probabilities of detection in the response stage, 8 out of 10 and 20 out of 33 are used to calculate a test statistic of 0.56. Since the test statistic is less than the critical value of 2.71, the two response stage detection rates are considered to be not significantly different at the 0.05 level of significance.

P_d^{disc}: OPEN FIELD versus MOGULS. Using the example data above to compare probabilities of detection in the discrimination stage, 6 out of 10 and 8 out of 33 are used to calculate a test statistic of 2.98. Since the test statistic is greater than the critical value of 2.71, the smaller discrimination stage detection rate is considered to be significantly less at the 0.05 level of significance. While a significant result does not prove a cause and effect relationship exists between the change in survey area and degradation in performance, it does indicate that the ability of demonstrator X to correctly discriminate seems to have been degraded by the mogul terrain relative to results from the flat open field using the same system.

APPENDIX B. DAILY WEATHER LOGS

TABLE B-1. WEATHER LOG

Weather Data from Yuma Proving Ground				
Date	Time, EDST	Average Temperature, °F	RH, %	Precipitation, in.
5/7/2003	01:00	66.1	33	0.00
5/7/2003	02:00	64.8	35	0.00
5/7/2003	03:00	63.2	36	0.00
5/7/2003	04:00	62.0	37	0.00
5/7/2003	05:00	61.2	37	0.00
5/7/2003	06:00	60.2	38	0.00
5/7/2003	07:00	62.1	37	0.00
5/7/2003	08:00	63.4	38	0.00
5/7/2003	09:00	66.0	36	0.00
5/7/2003	10:00	69.2	33	0.00
5/7/2003	11:00	72.1	30	0.00
5/7/2003	12:00	74.6	26	0.00
5/7/2003	13:00	76.5	25	0.00
5/7/2003	14:00	77.4	24	0.00
5/7/2003	15:00	77.4	23	0.00
5/7/2003	16:00	77.9	23	0.00
5/7/2003	17:00	76.6	25	0.00
5/7/2003	18:00	74.7	26	0.00
5/7/2003	19:00	71.8	33	0.00
5/7/2003	20:00	69.5	36	0.00
5/7/2003	21:00	67.8	40	0.00
5/7/2003	22:00	65.8	45	0.00
5/7/2003	23:00	64.9	46	0.00
5/7/2003	24:00	63.8	47	0.00
5/8/2003	01:00	62.6	47	0.00
5/8/2003	02:00	61.8	45	0.00
5/8/2003	03:00	59.7	45	0.00
5/8/2003	04:00	58.0	48	0.00
5/8/2003	05:00	56.8	53	0.00
5/8/2003	06:00	55.5	56	0.00
5/8/2003	07:00	57.5	53	0.00
5/8/2003	08:00	60.5	47	0.00
5/8/2003	09:00	65.1	40	0.00
5/8/2003	10:00	67.3	36	0.00
5/8/2003	11:00	71.1	30	0.00
5/8/2003	12:00	72.9	29	0.00
5/8/2003	13:00	74.4	27	0.00
5/8/2003	14:00	76.4	24	0.00
5/8/2003	15:00	77.2	23	0.00
5/8/2003	16:00	78.1	22	0.00
5/8/2003	17:00	77.3	24	0.00
5/8/2003	18:00	76.2	22	0.00
5/8/2003	19:00	73.5	22	0.00

TABLE B-1 (CONT'D)

Weather Data from Yuma Proving Ground				
Date	Time, EDST	Average Temperature, °F	RH, %	Precipitation, in.
5/8/2003	20:00	69.5	29	0.00
5/8/2003	21:00	67.3	28	0.00
5/8/2003	22:00	64.5	32	0.00
5/8/2003	23:00	62.8	32	0.00
5/8/2003	24:00	60.8	38	0.00
5/9/2003	01:00	58.6	43	0.00
5/9/2003	02:00	57.9	45	0.00
5/9/2003	03:00	56.1	49	0.00
5/9/2003	04:00	54.6	52	0.00
5/9/2003	05:00	55.1	52	0.00
5/9/2003	06:00	55.0	51	0.00
5/9/2003	07:00	56.7	49	0.00
5/9/2003	08:00	59.7	45	0.00
5/9/2003	09:00	62.9	39	0.00
5/9/2003	10:00	65.8	33	0.00
5/9/2003	11:00	67.7	29	0.00
5/9/2003	12:00	69.8	26	0.00
5/9/2003	13:00	71.4	22	0.00
5/9/2003	14:00	72.2	17	0.00
5/9/2003	15:00	73.0	18	0.00
5/9/2003	16:00	75.0	16	0.00
5/9/2003	17:00	76.0	14	0.00
5/9/2003	18:00	75.8	12	0.00
5/9/2003	19:00	73.5	20	0.00
5/9/2003	20:00	71.4	20	0.00
5/9/2003	21:00	68.5	22	0.00
5/9/2003	22:00	66.4	24	0.00
5/9/2003	23:00	65.9	23	0.00
5/9/2003	24:00	63.4	27	0.00
5/10/2003	01:00	60.5	34	0.00
5/10/2003	02:00	59.6	39	0.00
5/10/2003	03:00	56.9	42	0.00
5/10/2003	04:00	54.6	44	0.00
5/10/2003	05:00	53.2	43	0.00
5/10/2003	06:00	51.0	44	0.00
5/10/2003	07:00	58.1	32	0.00
5/10/2003	08:00	64.8	31	0.00
5/10/2003	09:00	68.4	25	0.00
5/10/2003	10:00	72.5	20	0.00
5/10/2003	11:00	76.3	15	0.00
5/10/2003	12:00	77.8	12	0.00
5/10/2003	13:00	79.8	13	0.00
5/10/2003	14:00	81.7	12	0.00
5/10/2003	15:00	81.8	12	0.00
5/10/2003	16:00	83.2	10	0.00

TABLE B-1 (CONT'D)

Weather Data from Yuma Proving Ground				
Date	Time, EDST	Average Temperature, °F	RH, %	Precipitation, in.
5/10/2003	17:00	83.3	10	0.00
5/10/2003	18:00	82.7	10	0.00
5/10/2003	19:00	81.6	10	0.00
5/10/2003	20:00	78.1	13	0.00
5/10/2003	21:00	75.4	15	0.00
5/10/2003	22:00	72.8	15	0.00
5/10/2003	23:00	68.9	18	0.00
5/10/2003	24:00	66.1	19	0.00
5/12/2003	01:00	71.2	21	0.00
5/12/2003	02:00	69.7	21	0.00
5/12/2003	03:00	67.2	23	0.00
5/12/2003	04:00	63.2	24	0.00
5/12/2003	05:00	63.4	25	0.00
5/12/2003	06:00	61.7	26	0.00
5/12/2003	07:00	65.9	21	0.00
5/12/2003	08:00	74.7	15	0.00
5/12/2003	09:00	81.7	14	0.00
5/12/2003	10:00	86.5	12	0.00
5/12/2003	11:00	89.3	10	0.00
5/12/2003	12:00	90.8	11	0.00
5/12/2003	13:00	93.0	8	0.00
5/12/2003	14:00	94.3	8	0.00
5/12/2003	15:00	95.7	8	0.00
5/12/2003	16:00	95.0	8	0.00
5/12/2003	17:00	94.7	9	0.00
5/12/2003	18:00	94.7	9	0.00
5/12/2003	19:00	92.2	9	0.00
5/12/2003	20:00	89.5	9	0.00
5/12/2003	21:00	85.3	10	0.00
5/12/2003	22:00	83.4	16	0.00
5/12/2003	23:00	80.4	17	0.00
5/12/2003	24:00	79.1	19	0.00
5/14/2003	01:00	76.0	21	0.00
5/14/2003	02:00	74.1	21	0.00
5/14/2003	03:00	72.4	22	0.00
5/14/2003	04:00	73.2	21	0.00
5/14/2003	05:00	71.8	21	0.00
5/14/2003	06:00	73.4	18	0.00
5/14/2003	07:00	73.2	19	0.00
5/14/2003	08:00	77.0	15	0.00
5/14/2003	09:00	82.6	13	0.00
5/14/2003	10:00	85.0	12	0.00
5/14/2003	11:00	88.9	10	0.00
5/14/2003	12:00	92.4	9	0.00
5/14/2003	13:00	94.8	8	0.00

TABLE B-1 (CONT'D)

Weather Data from Yuma Proving Ground				
Date	Time, EDST	Average Temperature, °F	RH, %	Precipitation, in.
5/14/2003	14:00	97.4	7	0.00
5/14/2003	15:00	96.2	6	0.00
5/14/2003	16:00	96.5	7	0.00
5/14/2003	17:00	94.6	9	0.00
5/14/2003	18:00	93.8	7	0.00
5/14/2003	19:00	92.0	8	0.00
5/14/2003	20:00	87.9	10	0.00
5/14/2003	21:00	84.4	11	0.00
5/14/2003	22:00	81.9	11	0.00
5/14/2003	23:00	79.4	12	0.00
5/14/2003	24:00	78.6	12	0.00
5/15/2003	01:00	62.5	39	0.00
5/15/2003	02:00	61.1	40	0.00
5/15/2003	03:00	60.0	44	0.00
5/15/2003	04:00	58.1	49	0.00
5/15/2003	05:00	57.9	51	0.00
5/15/2003	06:00	57.0	52	0.00
5/15/2003	07:00	60.8	46	0.00
5/15/2003	08:00	64.5	45	0.00
5/15/2003	09:00	68.3	37	0.00
5/15/2003	10:00	73.1	31	0.00
5/15/2003	11:00	78.0	26	0.00
5/15/2003	12:00	81.0	23	0.00
5/15/2003	13:00	83.4	22	0.00
5/15/2003	14:00	85.7	20	0.00
5/15/2003	15:00	87.5	18	0.00
5/15/2003	16:00	89.7	17	0.00
5/15/2003	17:00	89.8	17	0.00
5/15/2003	18:00	89.9	17	0.00
5/15/2003	19:00	88.4	18	0.00
5/15/2003	20:00	86.0	19	0.00
5/15/2003	21:00	83.4	21	0.00
5/15/2003	22:00	80.2	22	0.00
5/15/2003	23:00	75.7	25	0.00
5/15/2003	24:00	73.7	26	0.00
5/16/2003	01:00	73.9	29	0.00
5/16/2003	02:00	70.8	32	0.00
5/16/2003	03:00	69.2	32	0.00
5/16/2003	04:00	68.5	33	0.00
5/16/2003	05:00	66.7	35	0.00
5/16/2003	06:00	65.4	35	0.00
5/16/2003	07:00	70.5	30	0.00
5/16/2003	08:00	79.3	23	0.00
5/16/2003	09:00	86.4	17	0.00
5/16/2003	10:00	90.0	14	0.00

TABLE B-1 (CONT'D)

Weather Data from Yuma Proving Ground				
Date	Time, EDST	Average Temperature, °F	RH, %	Precipitation, in.
5/16/2003	11:00	92.0	14	0.00
5/16/2003	12:00	94.0	13	0.00
5/16/2003	13:00	95.5	12	0.00
5/16/2003	14:00	97.9	11	0.00
5/16/2003	15:00	98.9	11	0.00
5/16/2003	16:00	99.9	11	0.00
5/16/2003	17:00	99.4	12	0.00
5/16/2003	18:00	99.1	10	0.00
5/16/2003	19:00	97.7	11	0.00
5/16/2003	20:00	93.1	12	0.00
5/16/2003	21:00	87.8	14	0.00
5/16/2003	22:00	86.1	16	0.00
5/16/2003	23:00	83.0	18	0.00
5/16/2003	24:00	80.4	19	0.00
5/19/2003	01:00	79.3	19	0.00
5/19/2003	02:00	77.6	19	0.00
5/19/2003	03:00	75.2	20	0.00
5/19/2003	04:00	73.4	21	0.00
5/19/2003	05:00	71.6	24	0.00
5/19/2003	06:00	68.4	25	0.00
5/19/2003	07:00	74.2	23	0.00
5/19/2003	08:00	80.5	25	0.00
5/19/2003	09:00	84.5	24	0.00
5/19/2003	10:00	89.7	14	0.00
5/19/2003	11:00	94.4	11	0.00
5/19/2003	12:00	97.3	10	0.00
5/19/2003	13:00	99.8	8	0.00
5/19/2003	14:00	101.0	8	0.00
5/19/2003	15:00	101.1	8	0.00
5/19/2003	16:00	101.3	7	0.00
5/19/2003	17:00	101.9	7	0.00
5/19/2003	18:00	101.0	7	0.00
5/19/2003	19:00	99.1	8	0.00
5/19/2003	20:00	95.2	9	0.00
5/19/2003	21:00	91.4	11	0.00
5/19/2003	22:00	88.1	11	0.00
5/19/2003	23:00	83.8	13	0.00
5/19/2003	24:00	81.7	15	0.00
6/4/2003	01:00	81.0	19	0.00
6/4/2003	02:00	80.0	22	0.00
6/4/2003	03:00	78.0	22	0.00
6/4/2003	04:00	75.5	28	0.00
6/4/2003	05:00	75.1	32	0.00
6/4/2003	06:00	74.3	34	0.00
6/4/2003	07:00	77.1	32	0.00

TABLE B-1 (CONT'D)

Weather Data from Yuma Proving Ground				
Date	Time, EDST	Average Temperature, °F	RH, %	Precipitation, in.
6/4/2003	08:00	82.1	27	0.00
6/4/2003	09:00	87.3	22	0.00
6/4/2003	10:00	89.9	19	0.00
6/4/2003	11:00	93.9	15	0.00
6/4/2003	12:00	95.8	14	0.00
6/4/2003	13:00	98.5	13	0.00
6/4/2003	14:00	100.8	12	0.00
6/4/2003	15:00	102.5	12	0.00
6/4/2003	16:00	103.5	11	0.00
6/4/2003	17:00	103.4	10	0.00
6/4/2003	18:00	102.5	10	0.00
6/4/2003	19:00	100.0	10	0.00
6/4/2003	20:00	96.6	11	0.00
6/4/2003	21:00	94.1	11	0.00
6/4/2003	22:00	90.9	12	0.00
6/4/2003	23:00	86.7	14	0.00
6/4/2003	24:00	84.1	16	0.00

APPENDIX C. SOIL MOISTURE

SOIL MOISTURE LOGS (6 through 17, 19 through 22, and 28 through 30 May 2003)

Date	Time	Calibration Area Readings (%)					Time	Mogul Area Readings (%)					Time	Desert Extreme Area Readings (%)				
		0 to 6 in.	6 to 12 in.	12 to 24 in.	24 to 36 in.	36 to 48 in.		0 to 6 in.	6 to 12 in.	12 to 24 in.	24 to 36 in.	36 to 48 in.		0 to 6 in.	6 to 12 in.	12 to 24 in.	24 to 36 in.	36 to 48 in.
5/6/2003	0748	1.8	2.2	3.7	3.6	4.0	0807	1.7	2.0	3.4	4.0	4.1	800	1.7	2.0	3.5	3.9	4.0
	1237	1.8	2.2	3.6	3.6	4.0	1246	1.6	2.0	3.6	3.9	4.0	1254	1.7	2.0	3.4	3.9	4.1
5/7/2003	0723	1.8	2.2	3.6	3.6	3.9	0740	1.6	2.0	3.6	3.9	3.9	733	1.7	2.0	3.4	3.9	4.1
	1255	1.8	2.2	3.7	3.6	4.0	1310	1.6	2.0	3.5	3.9	4.0	1305	1.7	2.0	3.4	3.9	4.1
5/8/2003	0715	1.8	2.2	3.6	3.6	3.9	0724	1.6	2.0	3.6	4.0	3.9	732	1.7	2.0	3.4	3.9	4.1
	1243	1.8	2.2	3.7	3.6	3.9	1250	1.6	2.0	3.5	4.0	4.0	1258	1.7	2.0	3.4	3.9	4.1
5/9/2003	0623	1.8	2.2	3.6	3.6	3.9	0638	1.6	2.0	3.5	3.9	3.9	631	1.7	2.0	3.4	3.9	4.1
	1306	1.8	2.2	3.6	3.6	3.9	1315	1.6	2.0	3.5	3.9	3.9	1324	1.7	2.0	3.4	3.9	4.1
5/10/2003	0618	1.8	2.2	3.7	3.6	3.9	0626	1.6	2.0	3.5	3.9	4.0	634	1.7	2.0	3.4	3.9	4.1
	1203	1.8	2.2	3.6	3.6	3.9	1212	1.6	2.0	3.6	3.9	4.0	1221	1.7	2.0	3.4	3.9	4.1
5/12/2003	0630	1.8	2.2	3.7	3.6	3.9	0638	1.6	2.0	3.6	3.9	4.0	644	1.7	2.0	3.4	3.9	4.1
	1256	1.8	2.2	3.6	3.6	3.9	1305	1.6	2.0	3.5	3.9	4.0	1313	1.7	2.0	3.4	3.9	4.1
5/13/2003	0711	1.8	2.2	3.6	3.6	3.9	0719	1.7	2.0	3.6	3.9	4.0	726	1.7	2.0	3.4	3.9	4.1
	1312	1.8	2.2	3.7	3.6	4.0	1323	1.6	2.0	3.6	3.9	4.0	1332	1.7	2.0	3.4	3.9	4.1
5/14/2003	0630	1.8	2.2	3.7	3.6	4.0	0639	1.7	2.0	3.6	3.9	4.0	647	1.7	2.0	3.4	3.9	4.1
	1302	1.8	2.2	3.7	3.6	3.9	1312	1.7	2.0	3.6	4.0	4.0	1318	1.7	2.0	3.4	3.9	4.1
5/15/2003	0626	1.8	2.2	3.6	3.6	3.9	0640	1.7	2.0	3.6	3.9	4.0	648	1.7	2.0	3.4	3.9	4.1
	1302	1.8	2.2	3.7	3.6	4.0	1310	1.6	2.0	3.6	4.0	4.0	1318	1.7	2.0	3.4	3.9	4.1
5/16/2003	0622	1.8	2.2	3.7	3.6	3.9	0629	1.7	2.0	3.6	4.0	4.0	0637	1.7	2.0	3.4	3.9	4.1
	1250	1.8	2.2	3.6	3.6	3.9	1258	1.6	2.0	3.5	3.9	4.0	1305	1.7	2.0	3.4	3.9	4.1
5/17/2003	0610	1.8	2.2	3.7	3.6	3.9	0618	1.6	2.0	3.6	3.9	4.0	0626	1.7	2.0	3.4	3.9	4.1
	1319	1.8	2.2	3.6	3.6	4.0	1327	1.6	2.0	3.6	3.9	4.0	1334	1.7	2.0	3.4	3.9	4.1
5/19/2003	0600	1.8	2.2	3.6	3.6	4.0	0608	1.6	1.9	3.6	3.9	4.0	0615	1.7	2.0	3.4	4.0	4.1
	1306	1.8	2.2	3.7	3.6	4.0	1316	1.6	2.0	3.6	3.9	4.0	1324	1.7	2.0	3.4	4.0	4.1
5/20/2003	0534	1.8	2.2	3.7	3.6	4.0	0542	1.6	2.0	3.6	3.9	4.0	0550	1.7	2.0	3.4	3.9	4.1
	1311	1.8	2.2	3.7	3.6	4.0	1320	1.6	2.0	3.6	3.9	4.0	1326	1.7	2.0	3.4	4.0	4.1
5/21/2003	0547	1.8	2.2	3.7	3.6	4.0	0555	1.6	2.0	3.6	4.0	4.1	0603	1.7	2.0	3.4	4.0	4.1
	1301	1.8	2.2	3.7	3.6	4.0	1309	1.6	2.0	3.6	4.0	4.0	1316	1.7	2.0	3.4	4.0	4.1
5/22/2003	0535	1.8	2.2	3.7	3.6	4.0	0543	1.6	2.0	3.6	4.0	4.0	0550	1.7	2.0	3.4	4.0	4.1
	1303	1.8	2.2	3.7	3.6	4.0	1311	1.6	2.0	3.6	4.0	4.0	1318	1.7	2.0	3.4	4.0	4.1
5/28/2003	0722	1.8	2.2	3.7	3.6	4.0	0730	1.6	2.0	3.6	4.0	4.0	0743	1.7	2.0	3.4	4.0	4.1
	1210	1.8	2.2	3.7	3.6	4.0	1218	1.6	2.0	3.6	4.0	4.0	1225	1.7	2.0	3.4	4.0	4.1
5/29/2003	0645	1.8	2.2	3.7	3.6	4.0	0653	1.6	2.0	3.6	4.0	4.0	0700	1.7	2.0	3.4	4.0	4.1
	1222	1.8	2.2	3.7	3.6	4.0	1230	1.6	2.0	3.6	4.0	4.0	1237	1.7	2.0	3.4	4.0	4.1
5/30/2003	0600	1.8	2.2	3.7	3.6	4.0	0609	1.6	2.0	3.6	4.0	4.0	0616	1.7	2.0	3.4	4.0	4.1
	1239	1.8	2.2	3.7	3.6	4.0	1248	1.6	2.0	3.6	4.0	4.0	1255	1.7	2.0	3.4	4.0	4.1

APPENDIX D. DAILY ACTIVITY LOGS

Date	No. of People	Area Tested	Status Start Time	Status Stop Time	Duration, min	Op Stat Code	Operational Status	Operational Status-Comments	Track Method	Pattern	Field Conditions	
20030512	3	BLIND TEST GRID	735	1055	200	1	SET-UP/MOBILIZATION	SETTING UP EQUIPMENT	NA	NA	HOT	DRY
20030512	3	BLIND TEST GRID	1055	1145	55	2	COLLECTING DATA	EQUIPMENT WAS CALIBRATED USING METALLIC LOOP	GPS	LINER	HOT	DRY
20030512	3	BLIND TEST GRID	1145	1210	25	2	COLLECTING DATA	RUNNING BGT BIDIRECTIONAL EAST/WEST	GPS	LINER	HOT	DRY
20030512	3	BLIND TEST GRID	1210	1310	60	3	BREAK/LUNCH	LUNCH	NA	NA	HOT	DRY
20030512	3	BLIND TEST GRID	1310	1325	15	1	SET-UP/MOBILIZATION	SETTING UP EQUIPMENT	NA	NA	HOT	DRY
20030512	3	BLIND TEST GRID	1325	1330	5	2	COLLECTING DATA	EQUIPMENT WAS CALIBRATED USING METALLIC LOOP	GPS	LINER	HOT	DRY
20030512	3	BLIND TEST GRID	1330	1420	50	2	COLLECTING DATA	RUNNING BGT BIDIRECTIONAL NORTH/SOUTH	GPS	LINER	HOT	DRY
20030512	3	BLIND TEST GRID	1420	1455	25	3	BREAK/LUNCH	BREAK	NA	NA	HOT	DRY
20030512	3	CALIBRATION LANE	1455	1520	25	1	SET-UP/MOBILIZATION	SETTING UP EQUIPMENT	NA	NA	HOT	DRY
20030512	3	CALIBRATION LANE	1520	1525	5	2	COLLECTING DATA	EQUIPMENT WAS CALIBRATED USING METALLIC LOOP	GPS	LINER	HOT	DRY
20030512	3	CALIBRATION LANE	1525	1540	15	2	COLLECTING DATA	RUNNING CAL LANE BIDIRECTIONAL E/W	GPS	LINER	HOT	DRY
20030512	3	CALIBRATION LANE	1540	1600	20	1	SET-UP/MOBILIZATION	BREAKING DOWN EQUIPMENT EOD	NA	NA	HOT	DRY
20030513	3	CALIBRATION LANE	710	825	75	1	SET-UP/MOBILIZATION	SETTING UP EQUIPMENT	NA	NA	HOT	DRY

Note: Activities pertinent to this specific demonstration are indicated in highlighted text.

Date	No. of People	Area Tested	Status Start Time	Status Stop Time	Duration, min	Op Stat Code	Operational Status	Operational Status-Comments	Track Method	Pattern	Field Conditions	
20030513	2	CALIBRATION LANE	825	920	55	2	COLLECTING DATA	EQUIPMENT WAS CALIBRATED USING METALLIC LOOP	NA	LINER	HOT	DRY
20030513	2	CALIBRATION LANE	920	950	20	2	COLLECTING DATA	RUNNING CAL LANE BIDIRECTIONAL E/W	NA	LINER	HOT	DRY
20030513	2	CALIBRATION LANE	950	1005	15	3	BREAK/LUNCH	BREAK	NA	NA	HOT	DRY
20030513	2	CALIBRATION LANE	1005	1015	10	2	COLLECTING DATA	EQUIPMENT WAS CALIBRATED USING METALLIC LOOP	GPS	LINER	HOT	DRY
20030513	2	CALIBRATION LANE	1015	1055	40	2	COLLECTING DATA	RUNNING CAL LANE BIDIRECTIONAL E/W	GPS	LINER	HOT	DRY
20030513	2	CALIBRATION LANE	1055	1110	15	5	DOWNTIME DUE TO EQUIP MAINT/CHECK	CHECKING/DOWNLOADING DATA	GPS	NA	HOT	DRY
20030513	2	OPEN RANGE AREA	1110	1210	60	1	SET-UP/MOBILIZATION	SET-UP LAYOUT PERIMETER LINE	NA	NA	HOT	DRY
20030513	2	OPEN RANGE AREA	1210	1235	25	1	SET-UP/MOBILIZATION	SETUP EQUIPMENT	GPS	NA	HOT	DRY
20030513	2	OPEN RANGE AREA	1235	1305	30	3	BREAK/LUNCH	LUNCH	NA	NA	HOT	DRY
20030513	2	OPEN RANGE AREA	1305	1310	5	2	COLLECTING DATA	EQUIPMENT WAS CALIBRATED USING METALLIC LOOP	GPS	LINER	HOT	DRY
20030513	2	OPEN RANGE AREA	1310	1350	40	2	COLLECTING DATA	RUNNING OPEN RANGE GRIDS, D2,D3,D4,D5	GPS	LINER	HOT	DRY
20030513	2	OPEN RANGE AREA	1350	1400	10	3	BREAK/LUNCH	BREAK	NA	NA	HOT	DRY
20030513	2	OPEN RANGE AREA	1400	1438	38	2	COLLECTING DATA	RUNNING OPEN RANGE GRIDS, D2,D3,D4,D5	GPS	LINER	HOT	DRY
20030513	2	OPEN RANGE AREA	1438	1455	17	3	BREAK/LUNCH	BREAK	NA	NA	HOT	DRY
20030513	2	OPEN RANGE AREA	1455	1530	35	2	COLLECTING DATA	RUNNING OPEN RANGE GRIDS, D2,D3,D4,D5	GPS	LINER	HOT	DRY

Note: Activities pertinent to this specific demonstration are indicated in highlighted text.

Date	No. of People	Area Tested	Status Start Time	Status Stop Time	Duration, min	Op Stat Code	Operational Status	Operational Status-Comments	Track Method	Pattern	Field Conditions	
20030513	2	OPEN RANGE AREA	1530	1545	15	2	COLLECTING DATA	EQUIPMENT WAS CALIBRATED USING METALLIC LOOP	GPS	LINER	HOT	DRY
20030513	2	OPEN RANGE AREA	1545	1600	15	1	SET-UP/MOBILIZATION	BREAKDOWN EOD	NA	NA	HOT	DRY
20030514	3	OPEN RANGE AREA	630	745	75	1	SET-UP/MOBILIZATION	SETTING UP EQUIPMENT	NA	NA	WARM	HUMID
20030514	3	OPEN RANGE AREA	745	820	35	2	COLLECTING DATA	EQUIPMENT WAS CALIBRATED USING METALLIC LOOP	GPS	LINER	WARM	HUMID
20030514	3	OPEN RANGE AREA	820	830	10	2	COLLECTING DATA	RUNNING OPEN RANGE GRIDS, D2,D3,D4,D5	GPS	LINER	WARM	HUMID
20030514	3	OPEN RANGE AREA	830	840	10	5	DOWNTIME DUE TO EQUIP MAINT/CHECK	SWAPPED OUT BATTERY	GPS	NA	WARM	HUMID
20030514	3	OPEN RANGE AREA	840	915	35	2	COLLECTING DATA	RUNNING OPEN RANGE GRIDS, B2,B3,B4,B5	GPS	LINER	WARM	HUMID
20030514	3	OPEN RANGE AREA	915	945	30	1	SET-UP/MOBILIZATION	SETTING UP PERIMITTER LINES	NA	NA	WARM	HUMID
20030514	3	OPEN RANGE AREA	945	1015	30	2	COLLECTING DATA	RUNNING OPEN RANGE GRIDS, B2,B3,B4,B5	GPS	LINER	WARM	HUMID
20030514	3	OPEN RANGE AREA	1015	1025	10	5	DOWNTIME DUE TO EQUIP MAINT/CHECK	SWAPPED OUT BATTERY	NA	NA	WARM	HUMID
20030514	3	OPEN RANGE AREA	1025	1105	40	2	COLLECTING DATA	RUNNING OPEN RANGE GRID, B2,B3,B4,B5	GPS	LINER	WARM	HUMID
20030514	3	OPEN RANGE AREA	1105	1115	10	5	DOWNTIME DUE TO EQUIP MAINT/CHECK	SWAPPED OUT BATTERY	NA	NA	WARM	HUMID
20030514	3	OPEN RANGE AREA	1115	1140	25	5	DOWNTIME DUE TO EQUIP MAINT/CHECK	CHECKING/DOWNLOADING DATA	GPS	NA	WARM	HUMID
20030514	3	OPEN RANGE AREA	1140	1217	37	2	COLLECTING DATA	RUNNING OPEN RANGE GRID, B2,B3,B4,B5	GPS	LINER	WARM	HUMID

Date	No. of People	Area Tested	Status Start Time	Status Stop Time	Duration, min	Op Stat Code	Operational Status	Operational Status-Comments	Track Method	Pattern	Field Conditions	
20030514	3	OPEN RANGE AREA	1217	1309	52	3	BREAK/LUNCH	LUNCH	NA	NA	WARM	HUMID
20030514	3	OPEN RANGE AREA	1309	1339	30	2	COLLECTING DATA	RUNNING OPEN RANGE GRID, B2,B3,B4,B5	GPS	LINER	WARM	HUMID
20030514	3	OPEN RANGE AREA	1339	1344	5	3	BREAK/LUNCH	BREAK	NA	NA	WARM	HUMID
20030514	3	OPEN RANGE AREA	1344	1410	26	2	COLLECTING DATA	RUNNING OPEN RANGE GRID, B2,B3,B4,B5	GPS	LINER	WARM	HUMID
20030514	3	OPEN RANGE AREA	1410	1440	30	5	DOWNTIME DUE TO EQUIP MAINT/CHECK	SWAPPED OUT BATTERY	NA	NA	WARM	HUMID
20030514	3	OPEN RANGE AREA	1440	1510	30	3	BREAK/LUNCH	BREAK	NA	NA	WARM	HUMID
20030514	3	OPEN RANGE AREA	1510	1525	15	1	SET-UP/MOBILIZATION	SETTING UP PERIMITTER LINES	NA	NA	WARM	HUMID
20030514	3	OPEN RANGE AREA	1525	1535	10	2	COLLECTING DATA	EQUIPMENT WAS CALIBRATED USING METALLIC LOOP	GPS	LINER	WARM	HUMID
20030514	3	OPEN RANGE AREA	1535	1600	25	1	SET-UP/MOBILIZATION	BREAKING DOWN EQUIPMENT EOD	NA	NA	WARM	HUMID
20030515	3	OPEN RANGE AREA	635	720	45	1	SET-UP/MOBILIZATION	SETTING UP EQUIPMENT	NA	NA	COOL	DRY
20030515	3	OPEN RANGE AREA	720	815	55	2	COLLECTING DATA	EQUIPMENT WAS CALIBRATED USING METALLIC LOOP	GPS	LINER	COOL	DRY
20030515	3	OPEN RANGE AREA	815	917	62	2	COLLECTING DATA	RUNNING OPEN RANGE E/W GRIDS, C2,C3,C4,C5	GPS	LINER	COOL	DRY
20030515	3	OPEN RANGE AREA	917	925	8	5	DOWNTIME DUE TO EQUIP MAINT/CHECK	SWAPPED OUT BATTERY	NA	NA	COOL	DRY
20030515	3	OPEN RANGE AREA	925	955	30	2	COLLECTING DATA	RUNNING OPEN RANGE E/W GRIDS, C2,C3,C4,C5	GPS	LINER	COOL	DRY
20030515	3	OPEN RANGE AREA	955	1005	10	3	BREAK/LUNCH	BREAK	NA	NA	COOL	DRY

Date	No. of People	Area Tested	Status Start Time	Status Stop Time	Duration, min	Op Stat Code	Operational Status	Operational Status-Comments	Track Method	Pattern	Field Conditions	
20030515	3	OPEN RANGE AREA	1005	1015	10	2	COLLECTING DATA	RUNNING OPEN RANGE E/W GRIDS, C2,C3,C4,C5	GPS	LINER	HOT	DRY
20030515	3	OPEN RANGE AREA	1015	1025	10	2	COLLECTING DATA	EQUIPMENT WAS CALIBRATED USING METALLIC LOOP	GPS	NA	HOT	DRY
20030515	3	OPEN RANGE AREA	1025	1030	5	5	DOWNTIME DUE TO EQUIP MAINT/CHECK	DOWNLOAD DATA	NA	NA	HOT	DRY
20030515	3	OPEN RANGE AREA	1030	1035	5	5	DOWNTIME DUE TO EQUIP MAINT/CHECK	SWAPPED OUT BATTERY	NA	NA	HOT	DRY
20030515	3	OPEN RANGE AREA	1035	1045	10	3	BREAK/LUNCH	BREAK	NA	NA	HOT	DRY
20030515	3	OPEN RANGE AREA	1045	1105	20	1	SET-UP/MOBILIZATION	SETTING UP PERIMITTER LINES	NA	NA	HOT	DRY
20030515	3	OPEN RANGE AREA	1105	1138	33	2	COLLECTING DATA	RUNNING OPEN RANGE E/W GRIDS, G2,G3,G4,G5	GPS	LINER	HOT	DRY
20030515	3	OPEN RANGE AREA	1138	1144	6	3	BREAK/LUNCH	BREAK	NA	NA	HOT	DRY
20030515	3	OPEN RANGE AREA	1144	1220	36	2	COLLECTING DATA	RUNNING OPEN RANGE E/W GRIDS, G2,G3,G4,G5	GPS	LINER	HOT	DRY
20030515	3	OPEN RANGE AREA	1220	1300	40	3	BREAK/LUNCH	LUNCH	NA	NA	HOT	DRY
20030515	3	OPEN RANGE AREA	1300	1315	15	1	SET-UP/MOBILIZATION	SETTING UP PERIMITTER LINES	NA	NA	HOT	DRY
20030515	3	OPEN RANGE AREA	1315	1325	10	2	COLLECTING DATA	EQUIPMENT WAS CALIBRATED USING METALLIC LOOP	GPS	NA	HOT	DRY
20030515	3	OPEN RANGE AREA	1325	1345	20	2	COLLECTING DATA	RUNNING OPEN RANGE E/W GRIDS, F2,F3,F4,F5	GPS	LINER	HOT	DRY
20030515	3	OPEN RANGE AREA	1345	1352	7	3	BREAK/LUNCH	BREAK	NA	NA	HOT	DRY
20030515	3	OPEN RANGE AREA	1352	1400	8	5	DOWNTIME DUE TO EQUIP MAINT/CHECK	SWAPPED OUT BATTERY	NA	NA	HOT	DRY

Date	No. of People	Area Tested	Status Start Time	Status Stop Time	Duration, min	Op Stat Code	Operational Status	Operational Status-Comments	Track Method	Pattern	Field Conditions	
20030515	3	OPEN RANGE AREA	1400	1425	25	2	COLLECTING DATA	RUNNING OPEN RANGE E/W GRIDS, F2,F3,F4,F5	GPS	LINER	HOT	DRY
20030515	3	OPEN RANGE AREA	1425	1435	10	3	BREAK/LUNCH	BREAK	NA	NA	HOT	DRY
20030515	3	OPEN RANGE AREA	1435	1450	15	2	COLLECTING DATA	RUNNING OPEN RANGE E/W GRIDS, F2,F3,F4,F5	GPS	LINER	HOT	DRY
20030515	3	OPEN RANGE AREA	1450	1500	10	3	BREAK/LUNCH	BREAK	NA	NA	HOT	DRY
20030515	3	OPEN RANGE AREA	1500	1520	20	2	COLLECTING DATA	RUNNING OPEN RANGE E/W GRIDS, F2,F3,F4,F5	GPS	LINER	HOT	DRY
20030515	3	OPEN RANGE AREA	1520	1535	15	2	COLLECTING DATA	EQUIPMENT WAS CALIBRATED USING METALLIC LOOP	GPS	NA	HOT	DRY
20030515	3	OPEN RANGE AREA	1535	1600	25	1	SET-UP/MOBILIZATION	BREAKING DOWN EQUIPMENT EOD	NA	NA	HOT	DRY
20030516	3	OPEN RANGE AREA	635	700	25	1	SET-UP/MOBILIZATION	SETTING UP EQUIPMENT	NA	NA	COOL	DRY
20030516	3	OPEN RANGE AREA	700	715	15	1	SET-UP/MOBILIZATION	SETTING UP PERIMITTER LINES	NA	NA	COOL	DRY
20030516	3	OPEN RANGE AREA	715	745	30	2	COLLECTING DATA	EQUIPMENT WAS CALIBRATED USING METALLIC LOOP	GPS	NA	COOL	DRY
20030516	3	OPEN RANGE AREA	745	849	4	2	COLLECTING DATA	RUNNING OPEN RANGE E/W GRIDS, A2,A3,A4,A5	GPS	LINER	COOL	DRY
20030516	3	OPEN RANGE AREA	849	856	7	3	BREAK/LUNCH	BREAK	NA	NA	COOL	DRY
20030516	3	OPEN RANGE AREA	856	958	2	2	COLLECTING DATA	RUNNING OPEN RANGE E/W GRIDS, A2,A3,A4,A5	GPS	LINER	HOT	DRY
20030516	3	OPEN RANGE AREA	958	1013	15	3	BREAK/LUNCH	BREAK	NA	NA	HOT	DRY
20030516	3	OPEN RANGE AREA	1013	1020	7	5	DOWNTIME DUE TO EQUIP MAINT/CHECK	CHECKING/DOWNLOADING DATA	NA	NA	HOT	DRY

Date	No. of People	Area Tested	Status Start Time	Status Stop Time	Duration, min	Op Stat Code	Operational Status	Operational Status-Comments	Track Method	Pattern	Field Conditions	
20030516	3	OPEN RANGE AREA	1020	1035	15	1	SET-UP/MOBILIZATION	SETTING UP PERIMITTER LINES	NA	NA	HOT	DRY
20030516	3	OPEN RANGE AREA	1035	1140	5	2	COLLECTING DATA	RUNNING OPEN RANGE E/W GRIDS, E2,E3,E4,E5	GPS	LINER	HOT	DRY
20030516	3	OPEN RANGE AREA	1140	1155	15	3	BREAK/LUNCH	BREAK	NA	NA	HOT	DRY
20030516	3	OPEN RANGE AREA	1155	1200	5	5	DOWNTIME DUE TO EQUIP MAINT/CHECK	SWAPPED OUT BATTERY	NA	NA	HOT	DRY
20030516	3	OPEN RANGE AREA	1200	1236	6	2	COLLECTING DATA	RUNNING OPEN RANGE E/W GRIDS, E2,E3,E4,E5	GPS	LINER	HOT	DRY
20030516	3	MOGUL AREA	1236	1320	44	3	BREAK/LUNCH	LUNCH	NA	NA	HOT	DRY
20030516	3	MOGUL AREA	1320	1345	25	1	SET-UP/MOBILIZATION	SETTING UP PERIMITTER LINES	NA	NA	HOT	DRY
20030516	3	MOGUL AREA	1345	1400	15	2	COLLECTING DATA	EQUIPMENT WAS CALIBRATED USING METALLIC LOOP	GPS	NA	HOT	DRY
20030516	3	MOGUL AREA	1400	1407	7	1	SET-UP/MOBILIZATION	SETTING UP EQUIPMENT	NA	NA	HOT	DRY
20030516	3	MOGUL AREA	1407	1430	23	2	COLLECTING DATA	RUNNING MOGUL NORTH / SOUTH	GPS	LINER	HOT	DRY
20030516	3	MOGUL AREA	1430	1435	5	3	BREAK/LUNCH	BREAK	NA	NA	HOT	DRY
20030516	3	MOGUL AREA	1435	1510	35	2	COLLECTING DATA	RUNNING MOGUL NORTH / SOUTH	GPS	LINER	HOT	DRY
20030516	3	MOGUL AREA	1510	1530	20	1	SET-UP/MOBILIZATION	SETTING UP PERIMITTER LINES	NA	NA	HOT	DRY
20030516	3	MOGUL AREA	1530	1600	30	1	SET-UP/MOBILIZATION	BREAKING DOWN EQUIPMENT EOD	NA	NA	HOT	DRY
20030517	3	MOGUL AREA	650	722	32	1	SET-UP/MOBILIZATION	SETTING UP EQUIPMENT	NA	NA	HOT	DRY
20030517	3	MOGUL AREA	722	735	13	2	COLLECTING DATA	EQUIPMENT WAS CALIBRATED USING METALLIC LOOP	GPS	NA	HOT	DRY

Date	No. of People	Area Tested	Status Start Time	Status Stop Time	Duration, min	Op Stat Code	Operational Status	Operational Status-Comments	Track Method	Pattern	Field Conditions	
20030517	3	MOGUL AREA	735	755	20	1	SET-UP/MOBILIZATION	SETTING UP EQUIPMENT	NA	NA	HOT	DRY
20030517	3	MOGUL AREA	755	832	37	2	COLLECTING DATA	RUNNING MOGUL NORTH / SOUTH	GPS	LINER	HOT	DRY
20030517	3	YUMA EXTREME	832	915	43	1	SET-UP/MOBILIZATION	SETTING UP EQUIPMENT	NA	NA	HOT	DRY
20030517	3	YUMA EXTREME	915	1018	63	2	COLLECTING DATA	RUNNING YUMA EXTREME BIDIRECTIONAL E/W	GPS	LINER	HOT	DRY
20030517	3	YUMA EXTREME	1018	1043	25	3	BREAK/LUNCH	BREAK	NA	NA	HOT	DRY
20030517	3	YUMA EXTREME	1043	1113	30	2	COLLECTING DATA	RUNNING YUMA EXTREME BIDIRECTIONAL E/W	GPS	NA	HOT	DRY
20030517	3	YUMA EXTREME	1113	1131	18	5	DOWNTIME DUE TO EQUIP MAINT/CHECK	CHECKING/DOWNLOADING DATA	GPS	NA	HOT	DRY
20030517	3	YUMA EXTREME	1131	1135	4	5	DOWNTIME DUE TO EQUIP MAINT/CHECK	SWAPPED OUT FIELD COMPUTER	NA	NA	HOT	DRY
20030517	2	YUMA EXTREME	1135	1200	25	2	COLLECTING DATA	RUNNING YUMA EXTREME BIDIRECTIONAL E/W	GPS	NA	HOT	DRY
20030517	2	YUMA EXTREME	1200	1212	12	2	COLLECTING DATA	EQUIPMENT WAS CALIBRATED USING METALLIC LOOP	GPS	LINER	HOT	DRY
20030517	2	YUMA EXTREME	1212	1245	33	3	BREAK/LUNCH	BREAK	NA	LINER	HOT	DRY
20030517	2	YUMA EXTREME	1245	1300	15	1	SET-UP/MOBILIZATION	SETTING UP PERIMITTER LINES	NA	NA	HOT	DRY
20030517	2	YUMA EXTREME	1300	1316	16	1	SET-UP/MOBILIZATION	SETTING UP EQUIPMENT	NA	NA	HOT	DRY
20030517	2	OPEN RANGE AREA	1316	1335	19	2	COLLECTING DATA	RUNNING OPEN RANGE GRIDS B2,B3,B4,B5	GPS	LINER	HOT	DRY
20030517	2	OPEN RANGE AREA	1335	1415	40	2	COLLECTING DATA	CONDUCTED EQUIPMENT INTERFERENCE TEST	GPS	LINER	HOT	DRY
20030517	2	OPEN RANGE AREA	1415	1430	15	7	DEMOBILIZATION	END OF TEST	NA	NA	HOT	DRY

Note: Activities pertinent to this specific demonstration are indicated in highlighted text.

APPENDIX E. REFERENCES

1. Standardized UXO Technology Demonstration Site Handbook, DTC Project No. 8-CO-160-000-473, Report No. ATC-8349, March 2002.

2. Aberdeen Proving Ground Soil Survey Report, October 1998.

3. Data Summary, UXO Standardized Test Site: APG Soils Description, May 2002.

4. Yuma Proving Ground Soil Survey Report, May 2003.

5. Practical Nonparametric Statistics, W.J. Conover, John Wiley & Sons, 1980, pages 144 through 151.

APPENDIX F. ABBREVIATIONS

AEC	=	U.S. Army Environmental Center
APG	=	Aberdeen Proving Ground
ASCII	=	American Standard Code for Information Interchange
ATC	=	U.S. Army Aberdeen Test Center
DGPS	=	differential Global Positioning System
ERDC	=	U.S. Army Corps of Engineers Engineering Research and Development Center
ESTCP	=	Environmental Security Technology Certification Program
EQT	=	Army Environmental Quality Technology Program
GPS	=	Global Positioning System
JPG	=	Jefferson Proving Ground
MS	=	Microsoft
PDOP	=	Position Dilution of Precision
POC	=	point of contact
QA	=	quality assurance
QC	=	quality control
RMS	=	root mean square
ROC	=	receiver-operating characteristic
RTK	=	real time kinematic
SERDP	=	Strategic Environmental Research and Development Program
UXO	=	unexploded ordnance
YPG	=	U.S. Army Yuma Proving Ground

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